THE OCTOBER SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

OCTOBER, 1937

THE BRAIN FROM FISH TO MAN

A SERIES OF CULMINATING PHASES IN EVOLUTION

By Dr. FREDERICK TILNEY

PROFESSOR OF NEUROLOGY, COLUMBIA UNIVERSITY

IN a recent address I ventured to suggest that the human cerebrum is not yet a finished product; it is, in fact, only some intermediate stage in the ultimate development of the master organ of life.

This suggestion is based upon the evolutionary changes through which the brain has passed. Such changes have been the result of structural modifications which, beginning in the fish, have undergone progressive advances in amphibians, reptiles and mammals until they reached their present culmination in the brain of modern man.

A full discussion of these structural modifications would require a voluminous treatise, and therefore it is my purpose to single out certain striking cerebral features in which the effects of evolution are particularly clear.

At first glance it might appear presumptuous to attach such a traditionally objectionable word as "evolution" to the human brain. In order to avoid certain prevailing resistances, it may be said that evolution, as here conceived, embraces a much more comprehensive process than that largely current in popular thinking. The implications of this process are not limited to the anthropoids. No scientist to-day believes that any of the living monkeys or apes are ancestral to man. These animals belong to families totally divergent from the human family. For the most part, they have ascended well up into the trees. Here, doubtless, they will remain as unconcerned in human origin as they are above reproach for participation in it.

Whatever interest there is in evolution should not, therefore, center in the ape and monkey kinds. The line of our ancestry reaches far back of them through millions of years. We were in the making long before there were any apes on earth. They, in their tree life, merely showed the way which shaped our course toward humanity. To make the proper acknowledgment of our hereditary indebtedness we should recognize in our family tree that highly important line of mammals which first introduced the customs of tree living. Back of them are still older lines which deserve equal ancestral credit. Here are found those animals, without the existence of which we should never have arrived. Among these is that vast assortment of creatures which made their appearance in the Age of Reptiles. All these reptilians were, in their turn, indebted for existence to earlier amphibians and fish. Thus the true line of vertebrate evolution leads

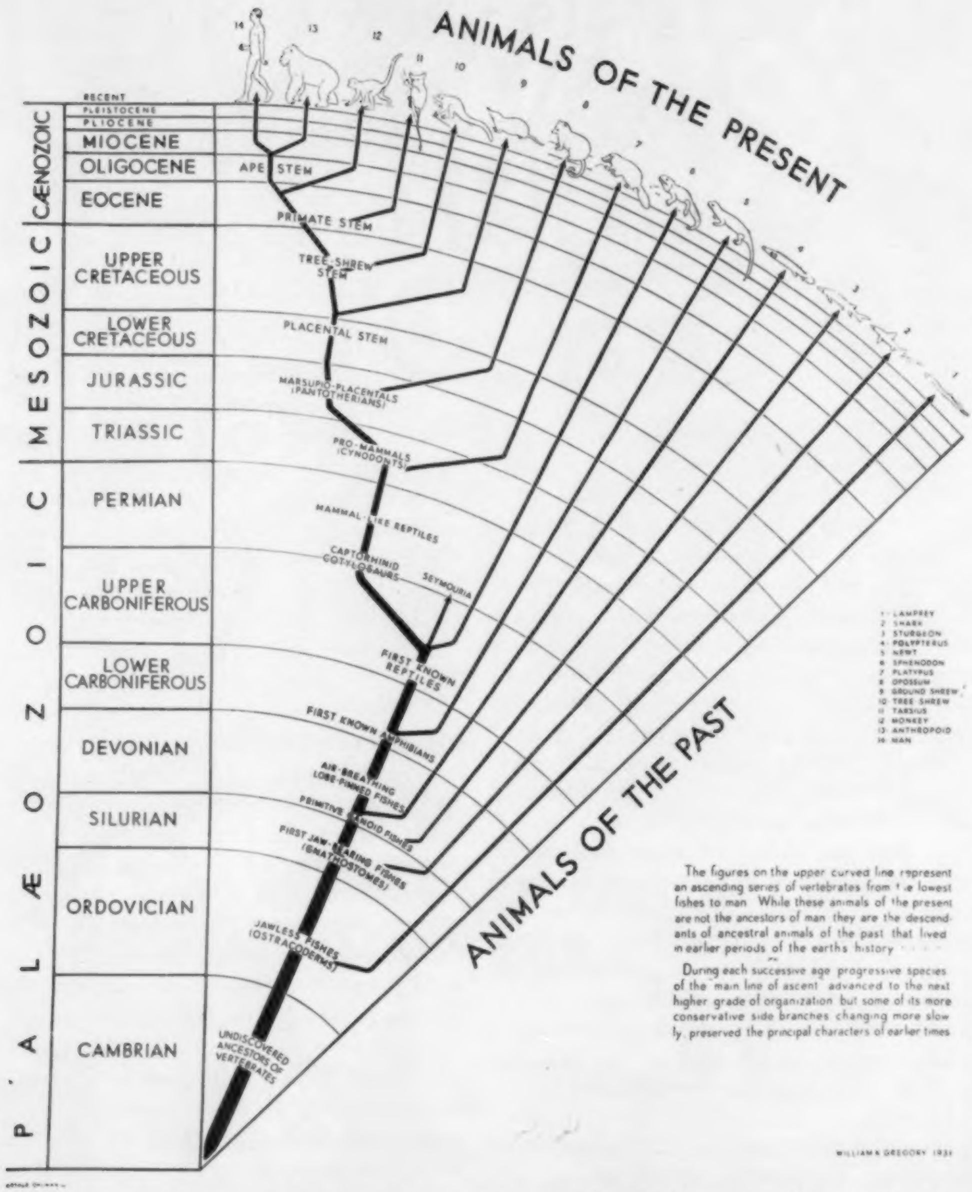


FIG. 1. A chart especially prepared by Professor William King Gregory to show the relations of animals past and present throughout the ages of the earth's history. While the ancestors of the present are not the ancestors of man, they are descendants of ancestral animals of the past. (1) lamprey, (2) shark, (3) sturgeon, (4) polypterus, (5) newt, (6) sphenodon, (7) platypus, (8) opossum, (9) ground shrew, (10) tree shrew, (11) tarsius, (12) monkey, (13) anthropoid, (14) man. Through the courtesy of the American Museum of Natural History.

from fish to man (Fig. 1). Not until we realize and sense the full meaning of this long lineage does the vital—the inspiring—significance of evolution become clear. In this way it is possible to appreciate the irresistible force which has carried animal life onward and upward through the ages. This force may be and probably is still at work. It may still carry us upward. In this light an evolution of the brain might prove acceptable. Incidentally, it may contain suggestions concerning further human advancement, possibilities for improvements and readjustments in human relations and behavior. In view of existing conditions such an idea might even be welcomed (Fig. 2).

Striking Constancy in the Manner of Brain Development in All Vertebrate Animals

The evidence of this evolutionary process includes numerous features connected with the genesis and growth of the brain, with its basic structural plan, with the gradual dominance acquired by the endbrain and with significant aspects of the external appearance and internal constituents of the brain as a whole.

Conspicuous among these features is the manner in which the brain, indeed the entire nervous system, develops. The ground-plan of this development is singularly constant in all vertebrates. It is exceedingly difficult, however, to detect where and when the actual beginning takes place. But somewhere in that indefinite cell mass which marks the embryonic dawn of a new life, this critical emergence occurs. Then the first signs of the brain can be recognized as a thin plate of ectodermal cells. This early condition marks the *neural plate stage* (Fig. 3).

A few hours later this plate is converted into a long, narrow groove bounded on either side by a rising neural fold, the *neural fold and groove stage* (Fig. 3).

FIG. 2. SIMILARITY OF BONY STRUCTURE FROM FISH TO MAN.

A little later the neural folds meet and fuse down the middle of the back and form a long tube, *the neural tube* (Fig. 3).

Even while this tube is forming, one end of it begins to expand. This is the head-end, and here the brain develops. The rest of the tube forms the spinal cord.

Almost from the beginning, the head or brain-end of the tube begins to specialize. By further expansions it forms

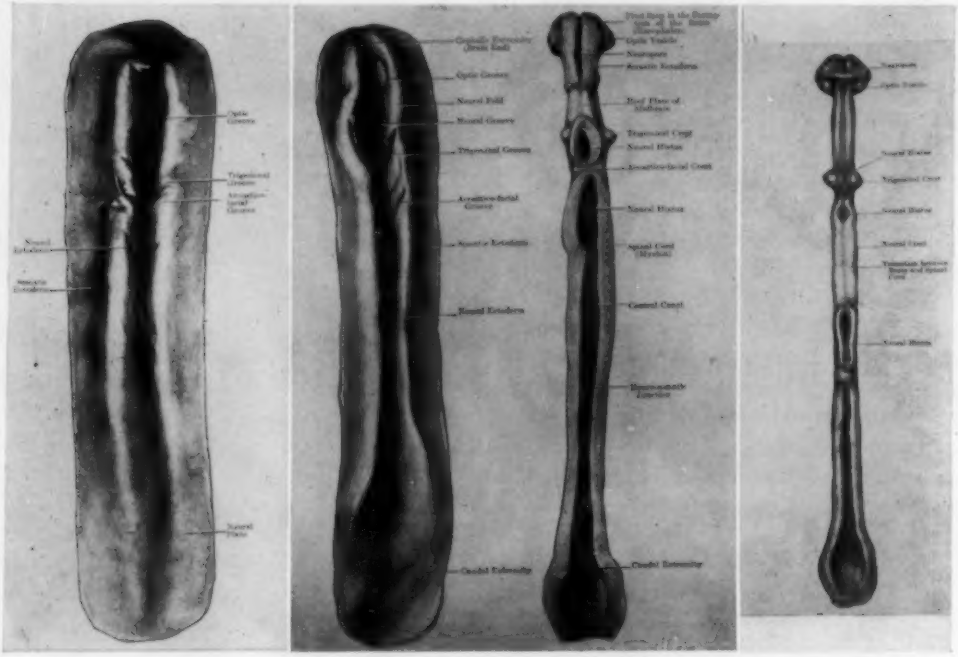


FIG. 3. DEVELOPMENT OF THE VERTEBRATE NERVOUS SYSTEM.
FROM LEFT TO RIGHT, LATE NEURAL PLATE STAGE, NEURAL FOLD STAGE AND EARLY TUBE STAGE, NEURAL TUBE STAGE.

three vesicles called the forebrain, the midbrain and the hindbrain. Each of these expanded divisions presides over certain definite functions of life.

All these important changes, however, are apt to seem static and devoid of their real dynamic significance until they are seen in the actually living and growing animal. It is possible to follow the processes of growth as they appear in motion picture films. Dr. William Beebe and Mr. John Tee-Van have succeeded in producing such a film. The motion picture is the result of one of the many ingenious methods of study for which Dr. Beebe is famous. The animal used in this case is the deep-sea eel, the species of which is not yet determined, although it is probably closely akin to the moray. After making the catch of the desired eggs, Dr. Beebe devised a means of isolating a single egg. When thus isolated the specimen was brought into a microscopic field at fairly high magnification. By using a moving-picture camera in connection with the microscope, photographs were taken of the growing embryo every minute for seven days. Approximately 10,000 consecutive exposures were made.

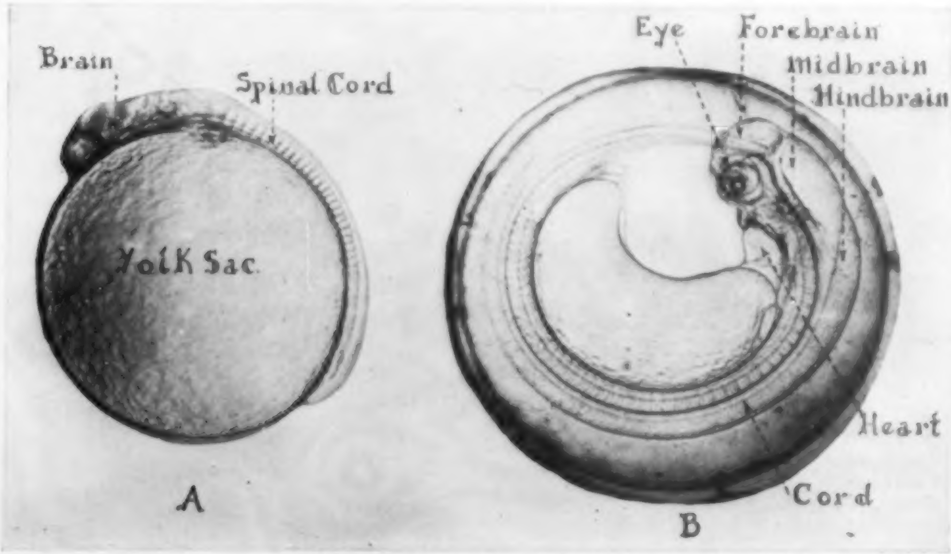
The process of growth begins with the rapid movement of cells which determines the gastrula and is quickly followed by the formation of the primitive streak, the neural plate, neural folds and groove and, finally, the neural tube. The embryo as it grows rises in profile above the yolk sac and as it lengthens progressively encircles the yolk of the egg (Fig. 4A and B). Fusion of the neural folds produces the neural tube. The head-end expands and begins to form the three primary vesicles of the brain. The remainder of the tube gives rise to the spinal cord, along the side of which a regular series of muscular segments makes its appearance. Eventually the heart begins to beat, at first spasmodi-

cally and then rhythmically; then the first irregular movements of the body occur and later become characteristically vermicular until they are sufficiently frequent and ample to start the fish on its free swimming career with the egg state entirely left behind. During this process of growth the neural and somatic ectoderms have undergone complete separation, the brain and spinal cord have been surrounded by an endoskeleton and a body musculature has been derived from the muscle segments.

Although the brain is first recognizable by the special expansions of the neural tube which form the three primary vesicles, it is only a brief time before these early dilated chambers become further modified to form five distinct vesicles. This change gives rise to what is known as the *ultimo-vesicular* stage, through which the brain of every back-boned animal passes in its growth.

Progressive Modifications in the Brain Vesicles

The subsequent modifications of these five ultimate vesicles are of such major importance as to require a familiarity with them, at least by name. Thus the *endbrain* consists of two relatively large sacs of neural tissue which open into either side of the *interbrain* by two apertures later to become the foramina of Monro. It is not difficult to anticipate that these endbrain sacs are destined to become the great hemispheres of the cerebrum. In their early development, however, they are not especially prepossessing features of the brain. Immediately behind the interbrain is the *midbrain,* and following it are the *hindbrain* and the *afterbrain.* Important as are these labels for the five cerebral divisions, it is equally essential to bear in mind the chief dynamic meaning of each vesicle. For example, the endbrain, in its most primitive form, is almost exclusively devoted to the sense of smell. This condition is true in all fishes. The interbrain takes charge of integrating sensory impressions coming in from the body. These impressions form the basis of what is, perhaps, the most important of all the senses, namely, *body sense.* The midbrain, in the lowest animals, predomi-



—Through the courtesy of Dr. William Beebe and Mr. John Tee Van

FIG. 4. EMBRYONIC STAGES IN THE DEVELOPMENT OF THE CENTRAL NERVOUS SYSTEM OF A DEEP SEA EEL.

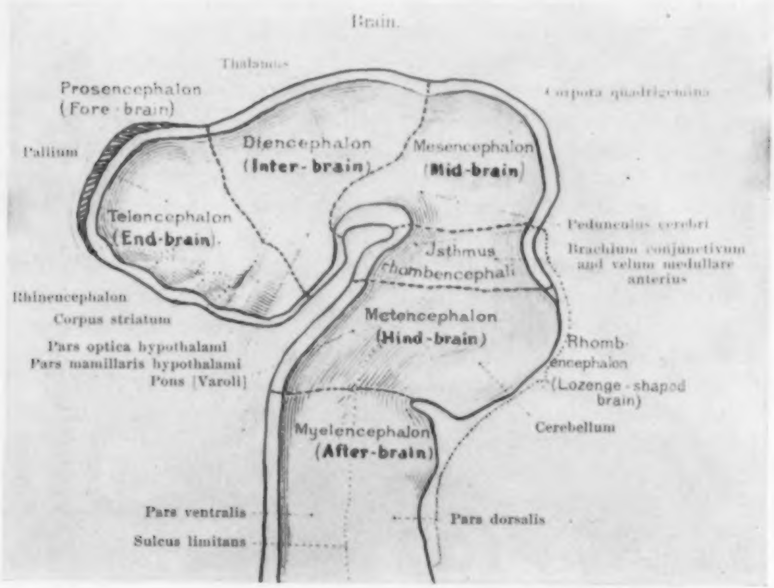


FIG. 5. THE FIVE PRIMITIVE VESICLES OF THE BRAIN (MODIFIED FROM SPALTEHOLZ).

nates in size over the other vesicles and has its great importance in the fact that it presides over the sense of sight. The functions of the hindbrain are body-balance and muscular coordination. The afterbrain regulates the activities which enter into the essence of life, such as breathing and beating of the heart.

The operating agents in all these five vesicles consist of nerve cells and the nerve fibers connected with these cells by means of which the brain carries on all

—Through the courtesy of the American Museum of Natural History

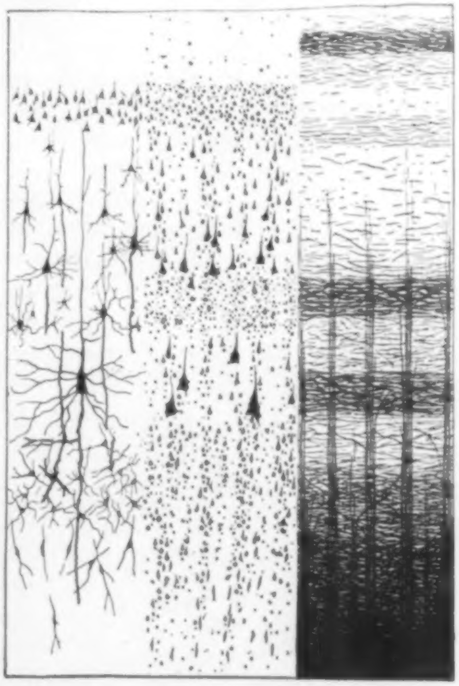
FIG. 6. LOBE-FINNED FISH SHOWING AN EARLY, PARTIAL ADAPTATION TO LIFE ON LAND.

its activities. If any analogy is at all permissible it might be said that these nerve cells are like minute batteries generating, transmitting and receiving nerve impulses.

The five-vesicle arrangement is the structural set-up, even in the lowest of vertebrates, the cyclostomes. It also holds good for all the fish. Not only is this architectural plan constant in fish, but the functional assignment to each vesicle is equally invariable. Indeed, so deeply committed are most of the fish to this structural plan and the functional executions dependent thereon that only a few of them retain any potentiality for further progressive development. In a very true sense the great order of sharks has developed a brain which, so to speak, has led them into a blind alley so far as evolutionary progress is concerned. In these animals the endbrain, which must be regarded as the vanguard in all progressive strides, is so irrevocably involved in the sense of smell that it has been deprived of the plasticity necessary to develop more complicated functioning. This structural inflexibility is likewise true of the bony fish. One exception to this uncompromising adherence to brain development may be found in the order of lung fish or lobe-fins (crossopterygians) (Fig. 6). Here the endbrain retains many characteristics of the primitive vesicles; it is less solid, more saccular in form and embedded in a rich meshwork of blood vessels. The very primitiveness of such an endbrain facilitated if it did not actually invite the modifications apparent in the next advance of cerebral evolution.

In amphibians like the frogs, a new sensory pathway for hearing made its appearance. This added mechanism created the need for additional developments in the brain, and then the reptiles, going a step further, introduced a more potent arrangement of nerve-cells by forming the earliest cortex of the endbrain.

The formation of a cortex of any kind in the brain seems to be the supreme device for producing the most efficient type of neural mechanism. The secret of cortical formation, whenever it occurs in the brain, appears to lie in the fact that the nerve cells and fibers are disposed in a series of layers and not diffusely clustered together. This stratification facilitates the highest degree of cooperation between the various layers of nerve-cells (Fig. 7). Such cortical arrangement of nerve-cells is actually an ancient device in the development of the brain. It has been a characteristic of the midbrain and, to a somewhat less degree,



Through the courtesy of Drs. Strong and Elwyn

FIG. 7. The stratified "cortical arrangement" of nerve cells and fibers in the neocortex which, by comparison with the "nuclear arrangement" in other parts of the nervous system, greatly amplifies the possibilities of intercellular communication and thus provides for more extensive utilization of nerve impulses.

of the hindbrain as far back as the very earliest vertebrates. But the appearance of nerve-cells disposed as stratified layers in the walls of the endbrain was an important departure in the development of the cerebrum—a decisive step toward the climax of brain evolution. Whatever other significance it may have had, the appearance of the early endbrain cortex in reptiles, called the *archicortex*, provided a strong impulse for the next great step which was taken by the mammals, namely, the eventual predominance of the endbrain. Once established, this predominance drew its chief potency from the introduction of what has been called the "last word" in grain organization, the *neocortex*.

Progressive Dominance of the Endbrain

These, in brief, are the stages through which the cerebrum has passed in reaching that transition which resulted in the predominance of the endbrain. The several phases of this progress may be accurately estimated by determining the comparative surface extent of the main vesicles in different classes of animals.

TABLE I
COMPARATIVE SURFACE EXTENT OF THE VESICLES IN DIFFERENT CLASSES OF ANIMALS

Animal	Encephalic index (per cent.)		
	Fore-brain	Mid-brain	Hind-brain
Fish—salmo-salar	19	43	38
Amphibian—fish	47	27	26
Reptile—alligator	41	25	34
Rodent—rabbit	68	0.5	27
Carnivore—dog	72.5	0.5	27
Anthropoid—gorilla	87	0.5	12.5
Human—man—2-year child	90.5	0.5	0.9

Transition from Nuclear to Cortical Predominance

In spite of the fact that cortical formation has an antiquity in the midbrain which goes back to the earliest fishes, the reactions of these animals were in no small measure controlled by the nuclear aggregations in the brain stem and spinal cord. In consequence of this largely nuclear regulation[1] of its energy turnover, the fish possesses a limited power to withhold its actions. Impressions from the outside world produce, in the main, almost immediate responses. In all events, the reactions tend to be rapid and preclude a large range of acts which characterize more deliberate and thoughtful behavior. The brain mechanism for this ample kind of life was not yet present in this stage of animal development. It began to make its appearance, however, when certain fishes (crossopterygians) assumed a partial adjustment to life on land. These adventurous pioneers managed to crawl out of the muddy waters at times when there was a lack of oxygen or when the supply of food was insufficient. They set on foot the progressive changes which ultimately gave rise to the fore and hind limbs of such amphibians as the frogs. When these latter animals made their appearance nearly all the fundamental problems of the vertebrate brain had been solved. There was still need for certain expansions and refinements in brain power, and these, in some part, were produced in the next succeeding Age of Reptiles. The ancient habit of highly rapid reaction which imposed serious limitations on the activities of the fish had not been entirely overcome

[1] For convenience of description "nuclear regulation" of behavior is used in contra-distinction to "cortical regulation" to indicate the difference between the more immediate reflex reactions characteristic of the spinal cord and the more highly coordinated control of the cerebral cortex. A nucleus in the central nervous system, such as the hypoglossal nucleus, the red nucleus and the facial nucleus in the brain stem or the extensor and flexor nuclei in the spinal cord, consists of an aggregation of nerve-cells clustered together to form a well-defined group. Their reactions are limited both in the time and variability in their responses. Cortical structures, on the other hand, have greater plasticity in all aspects of their reactions.

either by the amphibian or by the reptile. These animals still lacked the brain machinery needed for the more deliberate and varied reactions of the most effective kind of life. They had not altogether escaped from the ancient tyrannies of automatic response and reflex reaction. And yet the reptiles were headed in the right direction. Their acquisition of an archicortex was obviously a sign of progress. This primitive type of cortex is usually considered a development in the interest of the sense of smell. I have suggested that it is also connected with visceral sense, that is, with projections upon the endbrain intended to elaborate impressions from the stomach and intestines, the heart and lungs, the urinary and sexual apparatus.

There can be no doubt that the endbrain offers the greatest opportunities for cortical expansion, and here the mammals in time introduced the final detail of brain perfection. The outcome of this perfecting detail was the addition of a brain mechanism never possessed by animals before this time and in fact, in the strict sense, never possessed by animals other than the mammals. New and large areas of the cerebral hemispheres now came into existence to form the gray matter of the *neocortex* covering each hemisphere. In this way billions of new nerve cells were added to the brain. Their mere addition was of greatest importance. Even more important was their orderly arrangement in layers and their intimate connection by nerve fibers. With the development of this neocortex in mammals new and greater capacities to react became possible.

Progressive Modifications of the Neocortex in Mammals

When the mammals became possessed of that invaluable brain equipment, the new cortex, they at once began to turn it to their own advantage. It may be more correct to say that the neocortex opened up new avenues of opportunity which the mammals were quick to follow. At any rate, they became great adventurers and great specialists. What adventurers and specialists they have been is shown by the fact that they have occupied every one of the twelve habitat zones on land or in the water. Whales and porpoises have invaded the seas to make their dwelling places. Seals and their kind live partially on land and partially in the water. Hoofed animals inhabit the plains and forests. Bats and flying squirrels find conveyance through the air. Moles and burrowing animals have their homes underground. The meat-eaters have scented out every corner of the earth and carry on their hunting expeditions under the guidance of a wily brain. But however varied the mammals have been in their habits they have not all capitalized their neocortical powers to the same degree. In some animals, like the opossum, the rat and the rabbit, the pattern of the neocortex is extremely simple. The surface of the endbrain is smooth and unfurrowed. Because of this fact the brain is called *lissencephalic*. Certain mammals, by contrast, have brains which are more or less richly convoluted and hence called *gyrencephalic*. What is the significance of these two different types of mammalian hemispheres? In the gyrencephalic brain the surface is thrown into numerous irregular convolutions which greatly increase the areas capable of containing nerve cells and fibers. The lissencephalic brain, on the other hand, being by comparison less extensive in surface, is correspondingly less rich in nerve cells and nerve fibers. The functional meaning of these two types of brain is easily discerned in the differences of behavior between a gyrencephalic and a lissencephalic animal.

FIG. 8. RECONSTRUCTION OF THE BRAIN IN THE ADULT OPOSSUM TO ILLUSTRATE THE POSITION OF THE RHINAL FISSURE AND THE SHARP BOUNDARY WHICH IT FORMS BETWEEN THE NEOCORTEX AND THE PALEOCORTEX.

At this point it is appropriate to consider the cerebral assets possessed by the mammals in comparison with lower animals. There can be little doubt concerning the increased brain capacities of all mammalian orders. When the actions and capabilities of such mammals as dogs, horses, elephants or any of the cat family are compared with those of the bird or the snake or the fish, the marked differences speak for themselves. The dog, for example, has by comparison with lower vertebrates a greatly increased capacity for getting on in life. He is capable of adapting himself to many complications incident to his association with man. He has an ample and varied repertoire of accomplishments. He is capable of learning many intricate performances. In general, such adjustment and learning power is true of most of the higher mammals. It is particularly true of those having a highly developed neocortex. Even aquatic mammals, like seals, show a remarkable degree of adaptability. They are among the most interesting of trained performers. A casual glance is sufficient to show what an excellent, convoluted cortex they possess. Even in spite of their huge proportions and awkwardness, elephants are capable of remarkable adjustments. Their cortex is also highly developed.

Yet, however decisive the mammalian superiority of brain power may be by comparison with lower vertebrates, most mammals must be credited with distinct liabilities as well. They are held down by handicaps, restrictions and limitations of their own. They may be well adjusted to life in the water, in the air, on the plains, in the forest or underground, but their own specializations hold them to specifically restricted adaptations. Such things as may be done with hoof and paw, wing and flipper, head and trunk they are able to do well. But here their opportunities for progress cease.

Capacity for Adjustment Indicated by Three Great Fissures of the Brain

The story of progressive mammalian adjustment is distinctly outlined by three great fissures which occur in the hemispheres. The first of these is the *rhinal fissure*, which is the earliest to appear during development and also the most primitive of all cerebral fissures. It extends backward along the outer surface of the hemisphere from the base of the olfactory bulb to the occipital region. Its course runs nearer to the base than to the vertex of the hemisphere. In lower mammals, like the opossum, rat and rabbit, it is a prominent feature of the brain, but its true significance becomes clear only upon microscopic examination (Fig. 8). Then it is seen to form an important functional boundary line. It separates the neocortex, which is situated above it, from the paleocortex, originally an olfactory part of the brain, which lies below. As the neocortex gradually assumes its full development in higher mammals, the paleocortex is more and more forced downward into the basal surface of the brain and finally is lost to view on the lateral surface of the hemisphere. The gradual disappearance of the rhinal fissure goes hand in hand with the progressively increasing

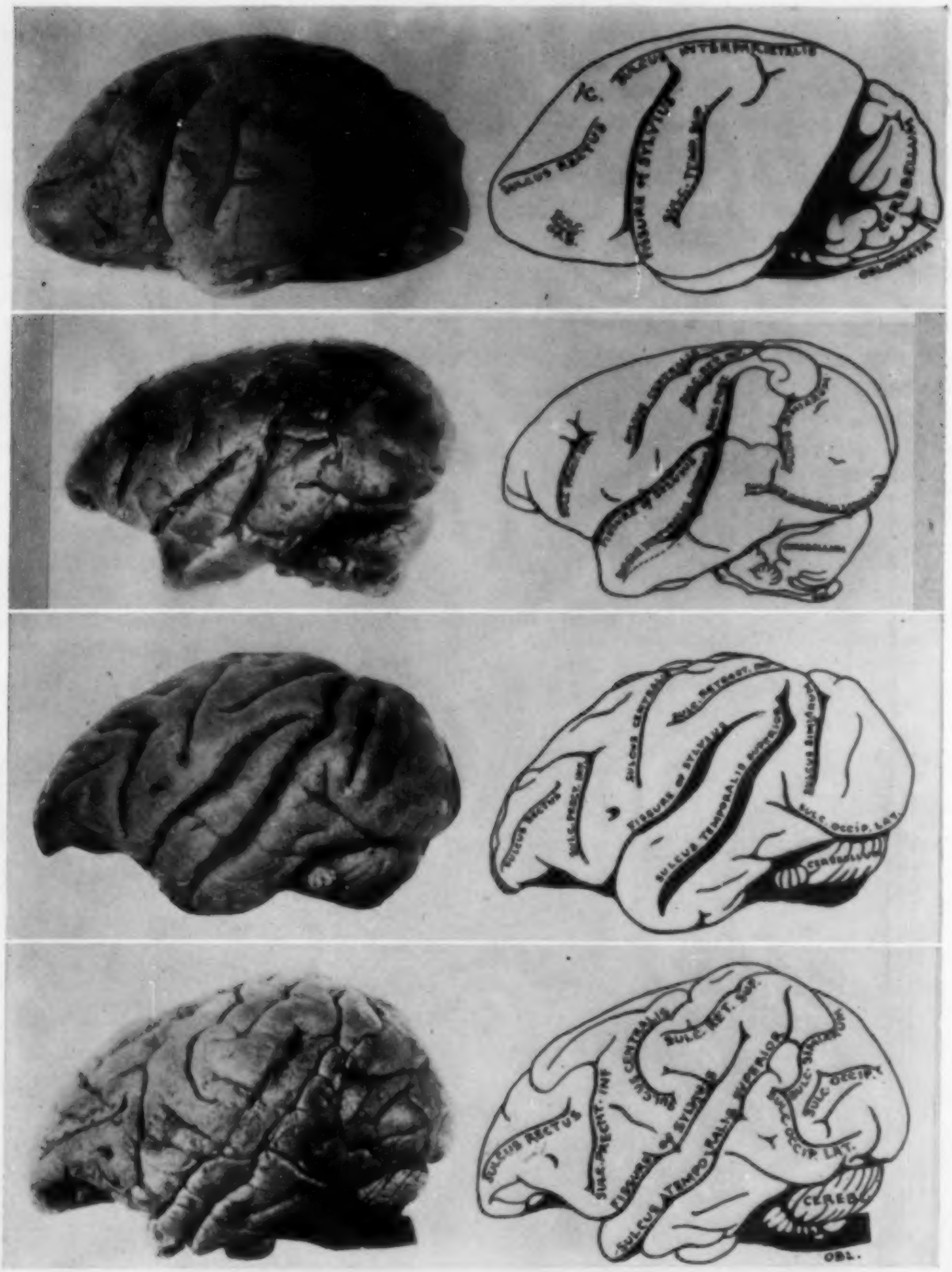
dominance of the neocortex in the control of the animal's behavior.[2]

The Sylvian fissure is the landmark which dominates the convolutional pattern of most mammalian brains. The convolutions of the hemisphere form more or less complete arches about it. If it were permissible to make a mammalian grouping into lower class, middle class and upper class mammals, the cerebral cortex of the first group would show a rhinal pattern, the second group would have a Sylvian pattern. The third group or upper-class mammals is distinguished by the presence of a long vertical fissure which passes obliquely across the outer surface of the hemisphere and divides this surface into two nearly equal halves. This dividing line is the *Rolandic fissure*, and the fissural pattern which it produces is the Rolandic pattern. No single factor has been more influential than this Rolandic fissure in determining the characteristics of the upper-class mammals which are known as the Primates. By them many of the handicaps which restricted other mammals were in large measure dissipated. This group of animals took its initial and main advantage from the fact that it assumed a life in the trees. Tree living of this kind began, according to Professor Gregory, with the late Paleocene representatives of the tree-shrew, and perfected arboreal primates first appeared in the lower Eocene. Notharctus is such a primitive primate. Its hands and feet were of the grasping type similar to more recent primates like lemurs and monkeys (Fig. 9).

[2] In discussing the fossil brains of some early tertiary mammals of North America, I have called attention to the significance and primitiveness of the rhinal fissure. This fissure appeared as a prominent feature in the brain casts of six different groups of mammals, including Amblypods, Condylarths, Perissodactyls, Artidactyls, Carnivores and Rodents. Most of these did not become extinct until the Oligocene. In the earliest and most primitive of these mammals, the rhinal fissure alone appears on the lateral surface of the hemisphere.

—Through the courtesy of Professor William K. Gregory

FIG. 9. NOTHARCTUS, A PRIMITIVE PRIMATE OF THE LOWER EOCENE PERIOD, WHOSE HANDS AND FEET SHOW THE EFFECTS OF ADAPTATION TO ARBOREAL LIFE.



LEFT HEMISPHERE OF THE BRAIN OF FOUR MONKEYS.

FIG. 10. 1st row (top), one of the lowest primates, the lemur monkey. c, sulcus centralis (fissure of Rolando); sulc. orb., sulcus orbitalis; sulc. temp. sup., sulcus temporalis superior. 2nd row, left hemisphere of the brain of the South American howling monkey, Mycetes seniculus. Obl, oblongata; ram. post., ramus posterior to superior temporal sulcus; sulc. prect. inf., sulcus precentralis inferior; sulc. ret. inf., sulcus retrocentralis inferior. 3rd row, the East Indian monkey, *Macacus rhesus.* Sulc. occip. lat., sulcus occipitalis lateralis; sulc. prect. inf., sulcus precentralis inferior; sulc. retroct. inf., sulcus retrocentralis. 4th row, the gibbon, *Hylobates hoolock.* Cerebl., cerebellum; obl., oblongata; sulc. occip., sulcus occipitalis; sulc. occip. lat., sulcus occipitalis lateralis; sulc. prect. inf., sulcus precentralis inferior; sulc. ret. sup., sulcus retrocentralis superior; sulc. simiarum, sulcus simiarum.

Dawn and Development of the Primate Brain

In many of their essential features these animals resemble men, and for that reason they are listed under the common name of *primates* in the same bracket with mankind. As in other spheres of life there are class distinctions among the primates. The lowest of them include the lemurs, tarsiers and all the New World monkeys. In the next higher rank are the monkeys of the Old World. The proanthropoid and anthropoid apes occupy the highest grade immediately below man. They include the gibbon, orang outang, chimpanzee and gorilla. In appearance and habits these animals are nearest to man. It is in their brain, however, that they make the closest approach to the human race. But this approach is achieved through a series of graded stages which have their beginning in the humble lemurs. It is here that the dawn of the primate brain may first be discerned. The lowest of the primate tribes show little advance over the lower mammals. The lemurs, standing farthest down the scale, give

—Through the courtesy of the American Museum of Natural History

FIG. 11. HABITAT GROUP, ORANG-OUTANG, SADONG RIVER, BORNEO.

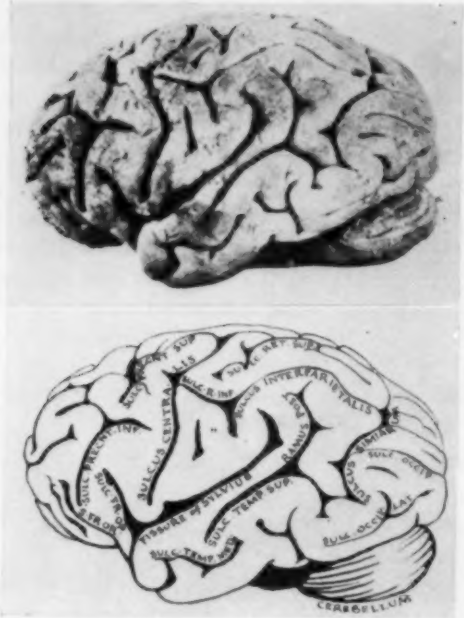


FIG. 12. LEFT HEMISPHERE OF THE BRAIN OF THE ORANG-OUTANG.

almost no signs that they are the real beginning of the long climb. Their endbrains are built definitely on the Sylvian pattern and although the rhinal fissure has almost entirely disappeared from the lateral surface of the hemisphere, only a faint trace of the Rolandic or central fissure can be detected (Fig. 10).

Brain and Behavior of the Lowest Monkeys

In following the progressive stages through which the endbrain passes in the primates, it will be necessary to observe the changes in certain lobes as well as the disposition of these three important fissures. In lemur the frontal lobe, which lies in front of the Rolandic fissure, has only the scantiest representation. The parietal, temporal and occipital lobes, on the other hand, are prominent.

Certain of the lowest monkeys, in the South American group (Cebidae) have, however, taken bold strides forward. The brain of the howling monkey, for example, has a definite primate appearance. No longer does the Sylvian pattern prevail. The Rolandic fissure has become conspicuous, and consequently the frontal lobe is now a prominent feature of the hemisphere. This advance can not be overestimated. Now for the first time it is possible to see foreshadowed that region of the brain upon which was founded not merely the Age of Man but more particularly the Age of the Frontal Lobe (Fig. 10). The parietal and temporal lobes are well represented, and the occipital lobe has acquired a new boundary which runs a somewhat spectacular course in the rest of the monkeys and apes. Professor Thorndike has made most careful studies of the behavior of several different species of South American monkeys. He believes that they represent a certain advance from the more generalized mammals toward man. All this is an advance due to the brain acting with increased delicacy.

Brain and Behavior of the Intermediate Monkeys

A good example of these monkeys is the Macacus or Indian monkey. Dr. Kinnaman, who has made studies of their mentality, believes that they have attained a higher level of intelligence than the New World monkeys. Professor Thorndike and Dr. Hobhouse maintain that macaques have some limited powers of reasoning. Professor Yerkes has expressed the view that the macaques may have a certain number of limited ideas.

The brain of these monkeys shows definite advances. Not only are the fissures deeper and better defined, but the several lobes are larger and more extensively convoluted (Fig. 10).

Brain and Behavior of Gibbon and Orang Outang

Manlike tendencies are still more pro-

nounced in the proanthropoid and anthropoid apes. Certain traits of this kind are obvious in the gibbon, which is able to stand up, walk and even run upon its hind legs. In the trees the locomotion of these animals is different from that of other monkeys. The gibbons, in this act, employ the arms almost exclusively, swinging from branch to branch with the legs tucked up under the body. This is an important and provocative change in the arboreal methods of transportation. In the first place, swinging from one limb to another elongated the forearms and fingers. The second effect produced by this kind of locomotion, which is called *brachiation,* was the progressive drawing of the body more and more into the erect posture (Fig. 10).

Another even more man-like ape is the orang outang. When full grown he stands a little more than four feet in height. Professor Yerkes has contributed important studies based on intelligence tests applied to the orang. These tests were devised on what is known as the "multiple choice system" and used with the partly grown orang, "Julius." This anthropoid continually endeavored to gain some insight into every test situation. Although slow, he showed that the brain had at length attained the development necessary to the production of real ideas (Fig. 11).

In the gibbon and more particularly

—Through the courtesy of the American Museum of Natural History
FIG. 13. HABITAT GROUP OF CHIMPANZEES.

in the orang the parietal, temporal and occipital lobes have increased in prominence. At this stage it is possible to speak of a well-developed frontal lobe. The gradual emergence of this lobe is one of the features in the anthropoid which leads up to the outstanding characteristic of the human brain (Fig. 12).

Brain and Behavior of the Chimpanzee

The chimpanzee has an established reputation for many valuable qualities. He is a performer of no mean talents and often as a comedian is able to earn a large salary. He is likewise famous as an acrobat. One of the best studies of the chimpanzee comes to us as an echo of the great war. Some years ago the Prussian Academy of Science established at Teneriffe in the Canary Islands a special station equipped for the study of the great manlike apes. It was here that Professor Köhler found himself during the war, and here he remained interned with nine chimpanzees for two years. As a result of many ingenious tests he found that the animals were able to learn the use of certain implements and even to construct instruments to aid in obtaining food. In many respects, such as playing and hunting, the animals had numerous human resemblances. Being of a buoyant and mirthful nature, the apes derived evident pleasure from clowning and masquerade. Perhaps their most constructive abilities were shown in their building propensities, which were brought into play under the urge of obtaining food. At such times they built tower-like structures by piling one box on another so that they could reach bananas suspended above their heads. Their cooperative efforts in these enterprises were invariably poor, for no sooner was the tower built than some mischievous operative would knock it down. Professor Yerkes's studies at Yale on the larger anthropoids and in his famous breeding station in Florida have added highly controlled tests to these early experiments. It is his opinion that even in the complex activities of cooperative effort the chimpanzee may acquire a degree of insight sufficient to make him an effective coworker in undertakings demanding the combined contributions of several individuals (Fig. 13).

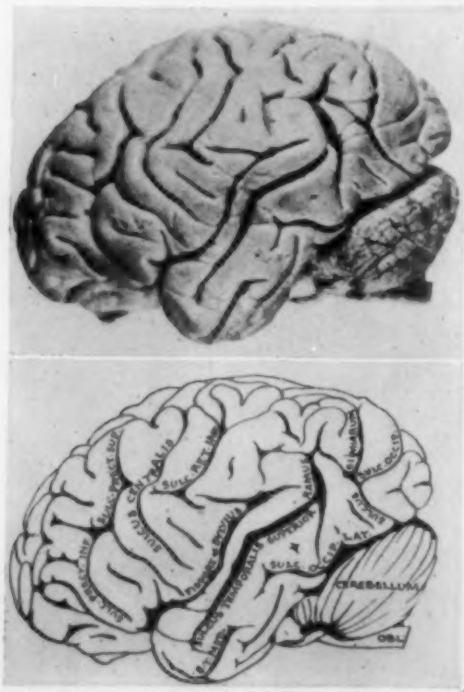


FIG. 14. LEFT HEMISPHERE OF THE CHIMPANZEE.

Should doubts remain concerning the superior, almost human capacities of the chimpanzee, these may soon be put at rest by inspection of his brain. This organ is human in miniature. It reveals the neocortical means by which this animal has acquired his new and extensive powers of learning, his greater understanding, his better capacity for adjustment.

The Rolandic pattern characterizes the fissural arrangement in the neocortex. All the fissures bear a close resemblance to those of the human brain. The lobes are highly convoluted and are disposed much as in man, except that the

—From Miss Alyce Cunningham's description of John Daniel's behavior
FIG. 15. THE YOUNG GORILLA, JOHN DANIEL I,
PORTRAYED IN A FRIENDLY ATTITUDE WITH A LITTLE PLAYMATE.

convolutions in chimpanzee are less complex. The frontal lobe is more extensive than in the orang outang or any of the lower primates (Fig. 14).

Brain and Behavior of the Gorilla

The largest member of the ape world is the gorilla. There is some dispute as to the place he occupies among the primates and also as to what rating his intelligence deserves. Neither of the questions can be settled at the present time. For many centuries the gorilla has had an unsavory reputation because of his savage disposition. The celebrated explorer, Mr. Carl Akeley, felt that this huge and ungainly animal has been done a real injustice in this respect. Instead of being an incorrigible brute he is in reality timid and retiring. Some young gorillas have been subjected to prolonged observation. One of them, called John Daniel the First, was found by Miss Alyce Cunningham in the show window as a Christmas advertisement of a well-

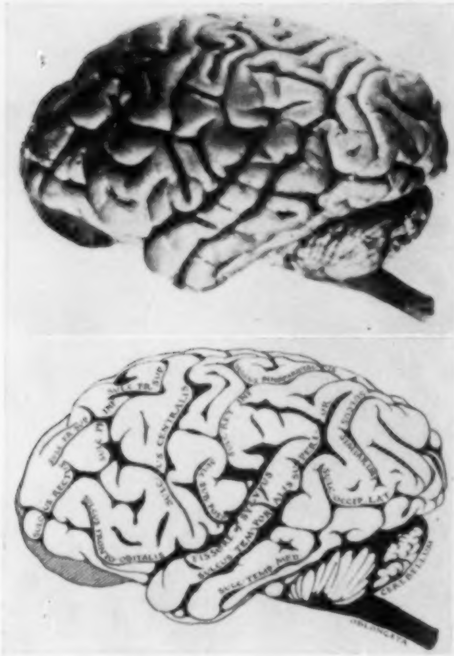


FIG. 16. LEFT HEMISPHERE OF THE YOUNG GORILLA, JOHN DANIEL I.

known London shop. The little animal was suffering from influenza and rickets. Miss Cunningham took this infant gorilla into her house and nursed him through his sickness. In the next three years he reached the weight of 112 pounds and attained the height of 3 feet 4½ inches. Meanwhile he acquired many of the adjustments necessary to fit him as an interesting if wholly unusual member of the household. Miss Cunningham has given us an excellent account of his life and habits (Fig. 15). John Daniel became gentle and affectionate in response to the tender care he received. At the end of six weeks he was thoroughly housebroken and allowed the freedom of the house. Generally speaking, he was not a thief. He manifested average honesty; but when it came to food, he always preferred to steal it. While growing up he showed a fondness for friends and strangers, especially when they visited him in his home. He always took afternoon tea with the family and liked his demi-tasse of coffee after dinner. The family's estimate of him was generally high. Incidentally John Daniel had a very good opinion of himself. He was quite well poised and self-contained. Nothing seemed to ruffle him. He appeared to believe that his own estimate of himself was shared by others and seemed confident that every one was delighted to see him. After his death Miss Cunningham secured another young gorilla, which she called John Daniel the Second. These two great apes resembled each other closely in their emotional reactions and in their responses to training. John the Second was, perhaps, a less likable individual and had a disposition more in keeping with the ancient repute of gorillas (Fig. 16).

Other young animals of this species have been studied in captivity. One of them, Congo the Second, has been the basis of the most careful and scientific study thus far made on this animal. In his book called "The Mind of a Gorilla" Professor Yerkes has given us another of his brilliant works on animal behavior. All his observations are illuminating and helpful in understanding the brain of this great troglodyte.

The gorilla's brain is larger and weighs more than that of any other anthropoid apes. In many other respects it is nearest to the brain of man. The Rolandic fissure forms the boundary of a well-defined frontal lobe. All the other fissures and lobes are more prominent and slightly more complexly convoluted than in the chimpanzee. If any comparative estimation can be justified at the present time it is that the gorilla's brain appears to be the most advanced of the apes and is, in fact, almost human.

(To be concluded)

PLANETARIUM OPERATION

By JAMES STOKLEY

DIRECTOR OF THE FELS PLANETARIUM OF THE FRANKLIN INSTITUTE, PHILADELPHIA

FOUR planetaria of the projection type developed by Carl Zeiss, Jena, are now in operation in the United States, nineteen are in operation in Europe, another is being built in Paris, and one opened earlier this year in Japan. This remarkable instrument, which has been fully described in earlier papers by the author and others, is therefore firmly established as an education feature. In several other American and Canadian cities projects to install them are under way. We of the Fels Planetarium have been in touch with many of these and are always glad to be of any possible help and to give suggestions gained from the four years in which we have been in operation.

The first problem to confront the prospective operators of a planetarium is that of the initial cost and then that of the income to maintain it. The cost will, of course, vary considerably, depending upon how elaborate an institution is desired. Erected and delivered in the United States, duty-free, the instrument costs 315,000 RM, or about $127,500 at the current rate of exchange. There are a few accessories that seem to be essential, and $500,000 seems a modest figure for the entire institution. This does not include real estate, which could generally be obtained at little or no cost. Not including interest and depreciation, the operating expenses would be about $25,000 per year. If this is to be provided from endowment, another $600,000 would be needed, so that a total outlay of $1,100,000 would provide for a planetarium and keep it running, without any dependence on admission charges.

No planetarium in this country, nor, as far as I know, abroad, is in this happy position of being maintained by an endowment. We are all more or less dependent upon admissions. The Adler Planetarium, in Chicago, has free demonstrations three days a week, and this is the only one in the United States to which adults are ever admitted without paying. At the Griffith Planetarium in Los Angeles, the Hayden Planetarium in New York and the Fels Planetarium, the only free admissions are to school children. The usual admission fee is 25 cents, though this varies from 15 cents, which is a special rate that is given in Philadelphia to school groups from outside the city limits, to 60 cents, charged at the Hayden Planetarium for reserved seats at evening demonstrations. Consequently, an attendance of about 100,000 paid admissions per year will be necessary.

Of course, the novelty of a planetarium at first attracts many people, and the attendance is high, then it levels off, subject, perhaps, to occasional stimulation by large conventions or expositions held in the city. In a very few cities, such as New York, there is a large transient population from which to draw—people visit it with the intention of "going places" and this affords a particularly favorable class. Most cities, like Philadelphia, however, are dependent more completely upon the local inhabitants. By comparing the population of the metropolitan area of the four present planetarium cities, it is possible to obtain some idea of what the attendance might be at first in other places.

THE ADLER PLANETARIUM AND ASTRONOMICAL MUSEUM, CHICAGO.
THIS WAS THE FIRST PLANETARIUM IN THE UNITED STATES. IT IS SHOWN HERE WITH THE APPROACH BUILT FOR IT AT THE TIME OF THE CENTURY OF PROGRESS EXPOSITION.

The population of Chicago and suburbs is given by the World Almanac as 4,364,000, and the paid attendance at the Adler Planetarium during the first year was 5.3 per cent. of this, or 230,943. Philadelphia's metropolitan population is 2,847,000 and the paid attendance at the Planetarium during the first year, ending November 6, 1934, was 192,000, or 6.7 per cent.

During the first year of operation, ending on May 14, 1936, the paid attendance at the Los Angeles planetarium was 252,706, about 11 per cent. of the metropolitan population of 2,318,000. That this represents mainly the transient population is shown by the fact that the maxima of attendance came at the very times of most visitors to the city. Incidentally, Dr. Alter, director, has pointed out that the attendance curve is very similar to that of the Huntington Library, so an institution of this type in a city might afford a good index of the prospects of a planetarium.

The first year of the Hayden Planetarium ended on October 2, 1936, with 691,136 persons having paid admission during that time. This is a record exceeded only by the Adler Planetarium during the first year of the Century of Progress exposition. It is 6.3 per cent. of the total of 11,000,000 people in New York's metropolitan area. Judging by these data, it therefore seems that any progressive city could count on a paid attendance during the first year of at least 5 per cent. of the combined population of the urban and suburban areas.

How much will the attendance drop during ensuing years? In Table I is given, through the courtesy of Dr. Philip Fox, director of the Adler Planetarium and Astronomical Museum, their attendance record for six years of operation. Because of adverse effects of the Century of Progress before and following it on account of construction and demolition, and the very favorable effect that it had while open, these can hardly

TABLE I

ATTENDANCE AND RECEIPTS AT THE ADLER PLANETARIUM AND ASTRONOMICAL MUSEUM

Year	Total[1]	Paid	Receipts
1st (1930–31) ..	731,108	230,943	$ 57,848.25
2nd (1931–32) ..	511,064	146,438	36,554.00
3rd (1932–33)[2]..	290,265	64,080	16,042.75
4th (1933–34)[3]..	925,156	852,070	212,843.00
5th (1934–35)[3]..	469,377	411,718	102,870.28
6th (1935–36)[2]..	222,876	35,602	9,022.25
7th (1936–37)[2]..	256,018	42,068	10,517.00
Totals	**3,405,864**	**1,782,919**	**$445,697.53**

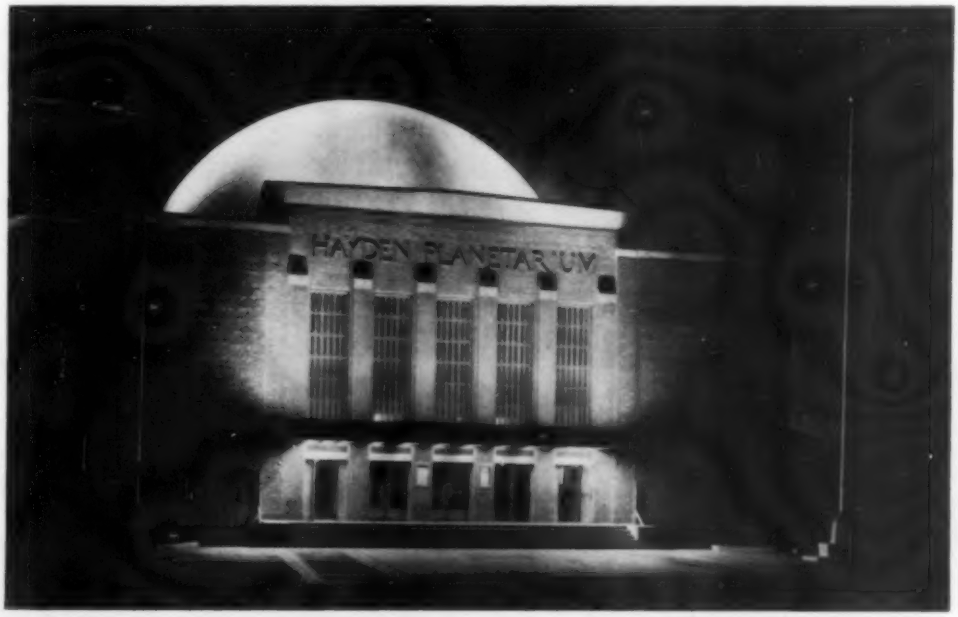
[1] Including visitors to the museum who did not attend a demonstration of the planetarium instrument.

[2] Dr. Fox states that "construction previous to, and demolition following the Century of Progress, with torn-up approach to the Planetarium, greatly affected attendance during 1932 and since the fair."

[3] 1933 and 1934 Century of Progress periods included, during which there were no free admissions.

be considered typical. Table II, however, presents a comparison of these figures for the pre-fair period with those of Philadelphia over the first three years, together with the records of the first two years in Los Angeles and the first in New York. It will be noted that in the second year of the Fels Planetarium paid attendance dropped 41.6 per cent. from the first year; but that the third dropped only 14.5 per cent. from the second. This seems to indicate that a level of attendance is being reached.

Considering these data, it seems that in general a city of less than 1,500,000 inhabitants in its metropolitan area would be unable to support a planetarium by admissions alone. If some local group, the school board, for instance, could contribute part of the expenses, any of the six cities not already provided, and with at least a million inhabitants to draw upon, should certainly be able to support one. These are: Boston, Cleveland, De-



THE HAYDEN PLANETARIUM,

PART OF THE AMERICAN MUSEUM OF NATURAL HISTORY, IN NEW YORK, WAS THE FOURTH IN THE UNITED STATES. THE BUILDING WAS ERECTED WITH FUNDS BORROWED FROM THE RECONSTRUCTION FINANCE CORPORATION.

TABLE II
COMPARISON OF ATTENDANCE AT AMERICAN PLANETARIA

Name and date opened	Total*			Paid				
	1st year	2nd year	3rd year	1st year	2nd year	Decline	3rd year	Decline
						Per cent.		Per cent.
Adler 1930 May 12	731,108	511,064	290,265	230,943	146,438	36.4	64,080	56.1
Fels 1933 Nov. 6	281,975	167,364	124,480	191,883	112,265	41.6	96,018	14.5
Griffith 1935 May 15	696,566	506,099		252,706	195,251	22.7		
Hayden 1935 Oct. 3	856,236			691,136				

* In the case both of the Adler and Griffith Planetaria, the figures for the total include visitors to the museum, who did not in many instances visit the planetarium itself. The total attendance at the Fels Planetarium and the Franklin Institute Museum during the first year (ending Nov. 5, 1934) was 548,987.

troit, Pittsburgh,[1] St. Louis and San Francisco. Then there are individual factors that would change the conditions in certain places. Washington, D. C., for example, is listed with a metropolitan population of 621,000, but because of the transient population, as well as of the proximity of Baltimore, with 949,000, it could undoubtedly support a planetarium with success.

The Hayden Planetarium was built with funds from the Reconstruction Finance Corporation, and is to be repaid to the government over a period of years. This has led many other cities to consider the possibility of doing likewise, or at least of borrowing the money and amortizing the debt, as well as paying operating expenses, out of the income. To do this in, let us say, 30 years, would necessitate at least double the income assumed above, and, other things equal, double the population. Using this as a criterion, Detroit seems to be the only city without a planetarium now that could possibly erect one in this manner.

But after all, why should we expect such an institution to pay for itself, any more than we expect a cash return from any of our museums or from our public schools? In modern cities, the glare and dust make the starry skies a much less conspicuous part of our environment than they were a century ago, and people forget about them. Yet how can a person be really educated unless he has at least a passing acquaintance with the universe in which we are living? Here at last the projection planetarium provides a means of showing the stars, in a manner that is even more convenient than the real sky itself, because it is not affected by bad weather or daylight, and the motions can be accelerated to show the changes of many years or even centuries in but a few minutes. The intangible benefits from a planetarium are certainly far greater than those from many things for which municipalities and other political subdivisions have spent many more dollars of the taxpayer's money.

A group erecting a new planetarium should certainly draw upon the experience of those already in operation. The type of projection dome is one thing that must be decided. The Adler Planetarium, like those in Europe, has one of stretched cloth. This has the disadvantage of getting dirty and requiring renewal, as it can hardly be cleaned in place. The Griffith Planetarium has a dome of acoustic tile, which is an improvement. The dome of the Fels Planetarium is of painted stainless steel sheets,

[1] While this article was in press plans were announced for a fifth American planetarium, to be placed in Pittsburgh. The instrument has been ordered, and actual work started. The building, including a technological museum, is being erected by the Buhl Foundation, which will also contribute toward the operating expenses.

bent to the proper curvature and perforated to prevent echoes. Its diameter is 20 meters. In the opinion of unprejudiced observers, this is the best planetarium dome in existence. Its success induced the builders of the Hayden Planetarium to adopt a somewhat similar construction.

In the Fels Planetarium, the dome is on the ground floor and is completely surrounded by other parts of the building. The space around the projection dome is very irregular and this contributes to the excellent acoustics, because there is little chance for sound to be focussed to cause an echo. In addition, a large proportion of the surrounding wall is covered with acoustic absorbing material. If it is desired to have an outer dome, this should not be concentric with the inner one, but should be of considerably longer radius of curvature. With a concentric outer dome, echoes are almost unavoidable, even if it is entirely lined with absorbing pads. These may absorb 98 per cent. of the incident sound, but the remaining 2 per cent., when concentrated from a large area, is sufficient to cause an objectionable echo.

Because of the fact that no windows or doors can be opened while lectures are in progress, ventilating equipment is necessary, and this should be of modern type, preferably to condition the air in winter and summer. Special pains must be taken to prevent any noise from the motors or fans being heard in the chamber, either through the ducts or the walls. Extra lighting should be provided. At the times of demonstration, all the illumination comes from the instrument, but the other lights are needed for cleaning the room, when the instrument is completely turned off; or when the chamber is used for another meeting.

The projection and sound equipment is another important accessory. Motion pictures as well as lantern slides can be used to advantage, and the projector must generally be in a fireproof booth, in which the ports should be glazed to keep the sound of the machines out of the chamber.

THE GRIFFITH OBSERVATORY IN LOS ANGELES

SHOWING THE ASTRONOMERS MONUMENT, IN FRONT OF THE MAIN ENTRANCE. THE PLANETARIUM IS UNDER THE LARGE CENTER DOME. THE SMALLER ONE TO THE LEFT CONTAINS A TWELVE-INCH TELESCOPE FOR THE USE OF VISITORS, WHILE THE ONE TO THE RIGHT HOLDS A COELOSTAT FOR REFLECTING SUNLIGHT BELOW.

Sound motion pictures will seldom be needed, though complete equipment for them can easily be installed, as many of the amplifiers will be provided for in the equipment for furnishing music. This is very desirable, both to entertain the visitors while waiting for the lecture to start, and also to give special effects by introducing it at appropriate times during lectures.

It is also easy to install a microphone that can be connected with the loud speakers, so that the voice of the lecturer may be reinforced if necessary. However, the acoustics of a planetarium ought to be so good that no competent lecturer should need such aid. A microphone can be used for two other very desirable functions, one of which is to supply deaf sets for the use of persons with defective hearing. The other is to operate a loud speaker in the projection booth so that the operator can follow the lecture. The best place for the loud speakers is at the top of the dome, for then their direction is least apparent to the audience, and the entire chamber seems to be permeated with music. The system should be capable of sufficient power to produce special sound effects when wanted.

Several institutions having planetaria, including the Franklin Institute, gave consideration to placing the instrument on an elevator, in the manner of the orchestra in a motion picture theater. Because of the expense, however, the decision has always been against it. We have often regretted that this was not done, for it would be most effective to have the audience enter the room and see nothing in the center, then to have the instrument appear at the start. Or the auxiliary lighting might be used when the audience entered, and the instru-

THE BENJAMIN FRANKLIN MEMORIAL AND THE FRANKLIN INSTITUTE IN PHILADELPHIA. AN IMPORTANT PART OF THE ASTRONOMICAL SECTION OF THIS GREAT TECHNOLOGICAL MUSEUM IS THE FELS PLANETARIUM, WHICH WAS THE SECOND IN THE UNITED STATES.

ment brought into place after the chamber was dark. This would greatly increase the realism, for it would not be apparent what was producing the stars. If the hole into which the instrument descended were to be covered, it would be easy to arrange the room for another meeting. At present most planetaria can be moved on tracks to one side for this purpose, though at the Franklin Institute, with another lecture hall in the building, no other meeting has ever been held in the planetarium chamber.

On several occasions, when presenting special lectures, we have erected a small stage at one side of the room on which to show certain exhibits. If such a stage were installed at the time of erection of the building, this would be much simpler. It should be below the horizon line of the dome, and might be about ten feet in width.

The chief need for a planetarium when once established is a steady attendance, and unless this is achieved, the institution will be a failure. School groups can be brought to special demonstrations, whether the students want to come or not, but this provides no excuse for not making them as interesting and attractive to the audience as any to paid attendance. The children can be splendid missionaries, spreading word at home and making their parents want to see this remarkable device.

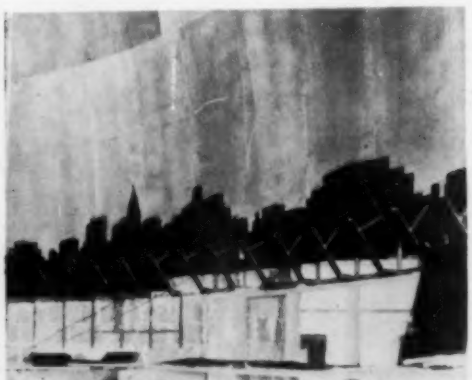
The visitors must be so interested that they will come again and again. In many of the German planetaria it has been the practice to give the same demonstration for a long period of time and to change it only after the attendance had dropped to a low figure. The American practice, on the other hand, has been to give new lectures every month. So many things can be demonstrated that they can not possibly all be shown at one performance. There are perhaps twenty different topics that can be treated. We, for example, devote two months a year to the constellation figures, pointing them out and telling some of the mythological stories associated with them. These are given in January and July, for the winter and summer evening skies, respectively, and are the simplest lectures presented. Others, such as one on "Time and Navigation" or another on "The Calendar," are necessarily somewhat more technical in their content, though, with the aid of the planetarium, the explanations can be kept simple enough for any one of normal intelligence to understand. Of course, it is assumed that the members of the audience will pay at least reasonable attention to the lecturer. In between these in technicality are such demonstrations as "Comets and Meteors," "Skies at the North Pole," "The Southern Skies," "The Planets and their Motions," etc.

In a city like New York, where there is such a large transient population, probably most of the planetarium visitors come only once, and it will be some time before the lecturer can assume that a large proportion of his audience has attended before. In Philadelphia, however, we find that from one third to a half of each audience is made up of what might be called "repeaters." Many persons have come three or four times, a few have attended practically every lecture since our opening, and one gentleman has come at least fifty times!

An effort is made to encourage people to come back again and again, and for this reason we try to make the lectures sufficiently different to attract them. Thus, we no longer give a detailed description of the instrument and its operation, as we did at first, but those who wish to know about its technical features may get information by asking questions of the lecturer after the demonstration. However, there are a few things that we include in every lecture. With one or

two exceptions, each starts, after a preliminary period of five to ten minutes, during which the lights are being dimmed to get the eyes of the audience dark-adapted, with the sunset of the present day. This gives the opportunity to point out the stars currently visible in the evening. Then, after passing through the night, the lecturer goes on to the particular topic under discussion that month. Each lecture is thus complete in itself, and a person who comes for the first time will hear a complete story.

However, there is necessarily enough similarity about such lectures to discourage many persons from coming more than four or five times at the most, and we believe that a partial answer to this problem is with what we have termed special



PART OF THE DOME OF THE FELS PLANETARIUM DURING CONSTRUCTION.

THE DOME WAS MADE OF PLATES OF STAINLESS STEEL, PERFORATED WITH SMALL HOLES IN ORDER TO BE PERVIOUS TO SOUND. ROCK WOOL PADDING ON THE WALLS IN BACK ABSORBS THE SOUND WAVES, AND PREVENTS ECHOES. THIS TYPE OF DOME, FIRST USED IN PHILADELPHIA, WAS ALSO EMPLOYED IN THE HAYDEN PLANETARIUM.

lectures. Each December since we opened, we have set the instrument back to the year 6 B.C., and have shown the conjunction of three bright planets which, according to Kepler's suggestion, was the original "star of Bethlehem." In 1935 and 1936 we gave this again, but added a special program of music and lighting effects, to give it something of an emotional as well as a scientific appeal. The response from the public was extremely gratifying.

Another special lecture, given during April, 1936, was called "How Will the World End?" In this we discussed theories that have been proposed by eminent scientists as to the ultimate fate of the Earth, and also introduced lighting effects and a musical background. This involved no departure from scientific accuracy, because we carefully pointed out that they were all merely theoretical possibilities and that other factors might prevent any one of them from coming to pass.

The late Dr. Oskar von Miller, founder of the Deutsches Museum, where the first planetarium was erected, once said that a planetarium by itself was like a motion picture theater with one film, and I think this is perfectly true. Important though the planetarium is in teaching the elements of astronomy, it does not tell the whole story, but should be supplemented whenever possible with observations of the actual sky. At least a small observatory should be associated with every planetarium. This need not increase the cost of the entire project more than a few per cent., for an extremely large instrument is not needed. In fact, a central city location, which is the best for the planetarium, to make it convenient of access, is one of the poorest locations for an observatory. An 8-inch or 10-inch refracting telescope, a 15-inch or 20-inch reflector, will do excellent work in showing the visitor the typical objects in the

heavens. If a telescope is installed, the first thought might be to place over it the usual observatory dome. For a research instrument the dome is highly desirable; for a museum it might be partly justified from the point of view of showmanship, for the public does expect an observatory to be covered with a dome. But from the standpoint of maximum value to the visitor, a sliding roof, with which the entire sky is exposed, is much to be preferred. With a dome, the sky is visible through a narrow slit, the visitor's view of the vicinity of the object at which he looks is greatly restricted. The sliding roof, on the other hand, allows him to orient himself with respect to familiar star groups in other parts of the sky. The next night, when he is looking at the skies from his home he can tell just where the planet or nebula is at which he gazed through the telescope.

THE OBSERVATORY OF THE FRANKLIN INSTITUTE.

IN THE FOREGROUND IS A 24-INCH REFLECTING TELESCOPE BY FECKER, AND IN THE REAR A 10-INCH REFRACTOR, BY ZEISS. THE SLIDING ROOF, OPERATED BY AN ELECTRIC MOTOR, EXPOSES TO THE VIEW OF VISITORS THE ENTIRE SKY, INSTEAD OF THE LIMITED AREA SEEN THROUGH THE SLIT OF THE USUAL DOME.

An observatory also offers an excellent opportunity for the small museum, in a community that can not support a planetarium, to take an interest in astronomy. In its establishment, if at all possible, the cooperation of local amateur astronomers should be secured. Recent years have seen a great revival in interest in astronomy, and there are many local astronomical societies throughout the country whose members are generally only too glad to help. Even when there is no society, a few interested persons could doubtless be found who would form the nucleus for such an organization. Closely related to such activity is the work of the amateur telescope makers. Since 1924 thousands of these instruments have been made, often by individuals working in the cellars of their homes. Others have worked in groups at some central, well-equipped headquarters, several of which have been established in connection with museums. After such amateurs become sufficiently expert, they might even be able to construct a telescope for the museum.

Far less expensive, even, than a small telescope is a good series of astronomical photographs. These can best be displayed as transparencies, which can be obtained from most of the large observatories. And now they can be supplemented with motion pictures. The McMath-Hulbert Observatory, an amateur institution now part of the University of Michigan, has specialized in astronomical films, and already has several excellent subjects available. These include sunrise and sunset on the Moon, Jupiter and the motion of its satellites, the solar eclipse of 1932 and disturbances on the Sun. Like the lapse-time cinema pictures of growing plants, the motion is accelerated, and it is possible to see in a

few minutes what would have required many hours, on the same night, of watching through a telescope. We have used these films to advantage both in connection with the planetarium demonstration and as separate "shows" in our astronomical exhibit hall. They are available in either 16 or 35 millimeters.

For astronomical museum exhibits there are many opportunities. Beautiful though the effect of the planetarium may be, it is a fact that it obtains its results by a geocentric mechanism and does not give the visitors a proper appreciation of the way that the planets move around the Sun. Consequently some sort of orrery should be used in conjunction with it. This might be either a small one, like that supplied by Michael Sendtner, of Munich, which we have in the entrance lobby, or a large one occupying a room nearly as big as the planetarium chamber itself, like the one at the Hayden Planetarium.

Many other working models can be prepared, to show an eclipsing binary star, one in which a bright and a dark component revolve around each other, the dark one periodically eclipsing the brighter. A model of a transit instrument on a turning globe, to show how time is determined from the stars; a Foucault pendulum, showing the rotation of the earth, and a model to show its action; a demonstration of the action of mirrors and lenses in forming telescopic images—these are but a few of the interesting exhibits that can be made, at relatively small cost. Any museum can have some department representative of astronomy if the authorities wish to do so.

THE ALPINE PASSES IN NATURE AND HISTORY

By Dr. WALTER WOODBURN HYDE

PROFESSOR OF ANCIENT HISTORY AND GREEK, UNIVERSITY OF PENNSYLVANIA

My first Alpine walk was over the Simplon Pass, which I crossed in July, 1899, from Iselle di Trasquera at the Italian base to Brigue on the Upper Rhone in Switzerland. While it is not one of the lofty passes, such as the Great St. Bernard or Stelvio, for it is only 6,582 feet high, it is one of the most beautiful in the Alps. Since that time I have walked over most of the major passes which lead across the Great Divide from France, Switzerland and Austria into Italy, and some of them twice, but the impression then made upon me by the Simplon Pass still lingers vividly in my memory.

In those days the great railway tunnel beneath the highway was under construction, for it was not opened to traffic till seven years later. The only way, therefore, to reach Brigue was over the pass on foot or in a diligence. While one can now—as I have since done—ride comfortably through the tunnel, a distance of nearly thirteen miles, in less than thirty minutes, the foot-journey over the top of the pass still remains a long day's walk of thirty miles.

The highway, built by order of Napoleon between 1801 and 1807, is a remarkable feat of engineering. Between Domo d'Ossola on the Tosa, twenty-seven miles below Iselle in Italy, and Brigue there are 613 bridges, 8 avalanche galleries and 20 refuges. Above Gondo, the first Swiss village on the ascent, it skirts the Gondo Gorge to Gabi, four miles beyond, one of the wildest defiles in the Alps. At one point here Napoleon's engineers had to tunnel a granite cliff whose perpendicular walls rise some 2,000 feet.

The views from the summit of the pass are among the finest in the Alps. From the Bellevue Simplon-Kulm Hotel, which in recent years has relieved the neighboring hospice of extending hospitality to all except indigent travelers, one looks down the descent into Switzerland surrounded by a galaxy of snow-clad peaks rising in gigantic walls on either side, while the view to the north is closed by the Sparrhorn and the loftier Nesthorn to the left and the conical summit of the Eggishorn to the right. Farther down, below the village of Berisal, the valley of the Upper Rhone comes into view, stretching for miles with its green meadows, ribbon-like river and snowy peaks in the distance.

Such mountain excursions I have found the pleasantest feature of a holiday in the "Playground of Europe." Not only do they afford delightful and exhilarating walks along splendid highways, but the novelty, it may be, of passing a night in some lofty inn or monastery. Some of the pass-routes reach altitudes of 8,000 feet or more, the Stelvio in the Central Alps, the highest motor-road in Europe, over 9,000. Its summit has long been provided with a hotel from which one can enjoy superb views down the gentle Italian slope and the almost perpendicular Tyrolean descent to Trafoi with the huge snow-capped Ortler immediately in front, the Oetztal Alps far to the north and the Bernina group to the southeast. Nearby is the Dreisprachenspitze, an eminence on the Pizzo Garibaldi, nearly 300 feet higher, where before the World War when seated on a boulder you could dis-

tribute your weight over three frontiers, those of Switzerland, Austria and Italy. You can still cover three linguistic areas —German, Italian and Raeto-Romanic!

It has always aroused my wonder and indignation that the thousands of tourists who visit Switzerland each summer have never learned to avail themselves of such mountain excursions. To almost a man they seem quite content with the lower levels, and to look up at the snowy peaks from such tourist-haunted centers as Geneva, Interlaken and Luzerne. They never dream that the views from the heights are incomparably grander and that many passes are easily reached by foot, and, if one wants more strenuous exercise, that there are plenty of minor passes reached by stony bridle-paths where one can be alone with nature at her best.

I have also found such walks a valuable preparation of heart and muscles for undertaking the climb of some major peak. Now that for reasons all my own I no longer can climb among the rocks and precipices of the Matterhorn nor the snows of Mont Blanc, the easy ascent of the passes has, in a measure, reconciled me to the loss. While the way may be long, every step in the clear atmosphere reveals a constantly changing panorama of ridges and peaks and glimpses into green valleys far below, and makes one rejoice to be alive. And even amid the discomforts of storms the mountain views are grand.

If one be adverse to such exercise he can at least drive over many passes in an autobus, the successor of the horse-drawn diligence of a generation ago, as these in fair weather are open and allow one to view the scenery with ease. But I have found nothing comparable with a foot-traverse and in the last few years I have made many. Thus in the summer of 1927 I crossed eight passes in the Western Alps, in that of 1929 a dozen in the Central Alps ranging from 6,000 to 9,000 feet in height, and in 1931 five more in the Austrian Alps north of the main chain. These latter are lower, but afford exquisite views of distant ridges and meadows gleaming in the sunlight. They are, moreover, known to few tourists.

But to me the greatest attraction of such walks is the knowledge that many of these passes have played important rôles in history from antiquity to our time. Such a story, beginning with the Romans in their expansion northward in the early Empire, covers a period of over two millennia. Further back we may even glimpse a little of their prehistoric use, as disclosed by archeology and historical inference.

Thus neolithic settlements once dotted the entire course of the Brenner in the Eastern Alps, just as villages do to-day. The early use of the Ligurian coast-road along the Riviera from southeastern France to Genoa is attested by myths of Heracles and King Cycnus—the latter in connection with the prehistoric amber-trade southward to the Mediterranean from the North Sea. Similarly, the early use of the Little St. Bernard into the Val d'Aosta is shown by its ancient name *Alpis Graia,* which the Romans, ever bad etymologists, wrongly translated as the "Greek" pass over which they believed that Heracles, the first mortal to cross the Alps, found his way while driving Geryon's oxen from Spain to Greece. Some of the eastern passes, notably the Brenner and Birnbaumerwald, because of their moderate heights, served as gateways through which many folk-wanderings reached Italy from Central and Eastern Europe long before Italy was guilty of Rome. In this way the earliest Indo-European invaders of Italy, the Terramare peoples, must have reached the valley of the Po from the Save and Drave, and ultimately the Danube, bringing with them the rudiments of Italian culture and a speech which was the forerunner of Latin.

And at the end of antiquity it was over these passes in the eastern Alps that many barbarian hordes came from the north in the fifth century to overwhelm the Roman Empire. Thus came the vanguard, the Visigoths under Alaric in 402 and again later to sack Rome in 410—the first time since the Gauls under Brennus had sacked it exactly 800 years before, and an undertaking which even Hannibal had not dared. Radagaisus with his barbarians came in 405 only to meet defeat. And in the middle of that terrible century came Attila the Hun, who boasted that grass never grew again where his horse's hoofs had trod, and destroyed Aquileia at the head of the Adriatic and was kept from sacking the Eternal City once more only through the persuasions of Pope Leo. Later, after Vandals under Gaiseric had reached Italy by sea from Africa and again destroyed Rome, still other Germanic tribes crossed the great mountain barrier, until finally Theodoric the Great with his Ostrogoths came in 489 and founded his Gothic kingdom of Italy, and old Rome was no more.

Thus the ancient history of the Alps, from the advent of the Romans to the foothills and their slow expansion over the summits northward to Rhine and Danube down to the extinction of their mighty Empire is alone full of interest and even romance. Then followed the story of the Alps through the Middle Ages and modern times, when the Alpine passes again became important in the story of Europe. It will, therefore, be profitable to recount a few of the chief events in that long story.

Our real knowledge of the Alps hardly antedates the coming of the Romans in the latter part of the third century B.C., long after Rome had become mistress of Italy. The very first mention of the Alps in European literature is found in the Greek historian Herodotus, who wrote in the middle of the fifth century B.C., but to him Alpis was only a river, a tributary of the Danube. A century later Aristotle called the chain by its earliest name—whether Celtic or Germanic—the "Arcynian Mountains," a name recalling that of the Hercynian Forest, which anciently spread over a great section of South Germany. But we do not meet the name Salpeis till the third century B.C., in the work of a little-known Alexandrian poet.

Curiously we do not yet know with certainty the origin of the name. The Romans naturally connected it with their adjective *albus,* but more probably the name is Celtic for "lofty mountains," as Celtic or Gallic tribes for centuries occupied both slopes, having reached Italy from eastern Switzerland by way of the Brenner some time near the close of the fifth century B.C. Their settlements finally extended from sea to sea, so that throughout Roman times North Italy was known as Cisalpine Gaul. Remains of their speech are still found in the Italian foothills.

Two centuries after the unheralded coming of the Celts occurred the most spectacular transit of the Alps in ancient or modern times, that of Hannibal and his elephants over a western pass in the fall of 218 B.C. In fact it was his crossing which first aroused the Romans to an active interest in their northern barrier, and it was his traverse far more than his supreme military genius which has left so indelible a memory on all posterity since. Thus the identification of his pass has been the subject of endless discussion in our time, when all sorts of books, both technical and semi-romantic, have been written on this theme from the historical, topographical, military, meteorological and economic points of view. And we feel certain that the vexed question will continue to intrigue investigators, since the data available are insufficient to render a decision agreeable to all.

Shall we ever know Hannibal's pass? All we know for certain is that in marching from the Rhone he must have crossed

a western one. Consequently, every pass west of the Simplon has had its defender —the *Encyclopedia Americana* even giving the glory to the latter itself, the most unlikely of all. We might quote the words of Douglass Freshfield, the sponsor of the Col de l'Argentière route: "For until a suit of Punic armor or an elephant's skeleton has been brought to light, the Alpine adventures of Hannibal must, I fear, continue as in Juvenal's day to interest boys and perplex schoolmasters." As an humble one of the latter I would reply that even such evidence would not be conclusive, since it might equally fit the pass used by Hasdrubal when, eleven years later, he came to the aid of his more illustrious brother—and that pass is shrouded in even greater mystery.

While the traverse of an Alpine pass by an army has ever been regarded as a major military exploit, that of Hannibal is remarkable not because of his "tanks" of that day, I mean his elephants, nor the hostility of the mountaineers, nor lack of food and fodder, nor even of a road, but merely because of the lateness of the season, at the end of October, when snow and cold on any pass are a menace. A few weeks earlier would have robbed the exploit of much of its glamor, as various Celtic tribes had crossed the mountains long before with their women, children and animals, and seemingly without difficulty.

To-day, after two centuries of learned wrangling, the route of the Carthaginian seems to be narrowed chiefly to one of three passes. Livy's account, written two hundred years after the event by the most imaginative of Roman historians but by one who knew nothing of the terrain involved, has Hannibal ascend the Durance from the Rhone, which would, if there were not grave difficulties in the way, certainly lead him over the Mt. Genèvre. The more prosaic Greek historian, Polybius, who was born during the Hannibalic War, had lived in Rome where he "questioned persons actually engaged in the events" and had in person "gone over the Alpine pass," seems to have him ascend the Isère from near Valence on the Rhone, which would as certainly lead him over the Little St. Bernard or some nearby pass.

Both these routes have had their henchmen—the Mt. Genèvre from Gibbon in the eighteenth century to W. A. B. Coolidge, the latter a practical mountaineer who advocated it only after crossing every possible pass; the Little St. Bernard from Bréval in the eighteenth century, through Niebuhr, Mommsen and Kiepert in the nineteenth, and down to Lenschau and others in the twentieth.

Unfortunately neither of these routes has an eminence from which Hannibal could have shown the plains of Italy to his band of "emaciated scarecrows," as both Livy and Polybius have him do. For this reason recently a by-pass, the Col Clapier leading from Bramans in France to Susa on the Italian descent of the Mt. Genèvre, which does fulfil this condition, has been advocated especially by French military critics of Hannibal. However, it is nearly a thousand feet higher than the Little St. Bernard and two thousand higher than the Mt. Genèvre, and besides its Italian descent for some 4,000 feet from the summit is by a zigzag rocky stairway down which it seems impossible that his elephants could have gone. It may, therefore, be better to regard the incident of the view as a fiction of Polybius copied by Livy, and to accept the Little St. Bernard as the logical route for the world's greatest commander to have followed.

Early in the next century, if not sooner, the Romans were first attracted to the foothills by the mineral wealth of the Celts, especially the gold of the Salassi in the Val d'Aosta and, later, the iron of the Taurisci in the Tyrol north of the Eastern Alps. Thus here, as later in Gaul and elsewhere, Roman merchants preceded Roman soldiers. But the

legions were sure to follow, for soon the Romans came to repel invaders.

The first of these invaders were the Cimbri and their kinsmen the Teutones, the earliest of the barbarian hordes from the north who came in historic times in search of a southern home. In their long trek from Jutland on the North Sea southward they arrived in Noricum (Austria) with the intention of reaching the Po valley over the Eastern Alps. In 113 B.C. a Roman army sent north to meet them was defeated beyond the Alps, but fortunately the invaders did not then proceed further south, but soon marched westward into Gaul. Here in the next few years they defeated three more Roman armies and then crossed into Spain. Later they returned to Gaul, and the vast horde divided; the Teutones tried to enter Italy from the northwest only to be destroyed by the Roman consul Marius in 102 B.C. on the Rhone above Marseilles, while the Cimbri on reaching Italy from the northwest were annihilated the next year by Marius and his colleague near Vercelli. It was their German kin who, over five centuries later, as already mentioned, exacted a terrible vengeance, when they crossed the Alps in successive waves and overwhelmed Italy and the Empire.

Finally the Romans came as conquerors and administrators of the Alpine tribes and areas further north. But it was not till Caesar's Gallic wars—still the perplexity of school boys—that Rome felt the need of subduing the mountaineers in order to control the pass-routes into Gaul and Helvetia. Caesar's plans, cut short by his assassination in 44 B.C., were carried out by his grand nephew, known to us as Augustus, the founder of the Roman Empire. In a desultory war begun around 25 B.C., but whose major operations were completed by the emperor's stepsons, Tiberius and Drusus, in 16–14 B.C., the entire chain became a part of the Roman state.

We need mention only one incident in that war, the subjugation by the Roman commander Varro of the brave Salassi who had long been settled in the beautiful Val d'Aosta just under the Alps. For the incident is typical of the severity shown by Rome in building her empire. Many ancient historians have told it, but I quote a brief paragraph from the later Cassius Dio, who lived in the third century: "After forcing them to come to terms, Varro demanded a certain sum of money, as if he was going to impose no other punishment; then sending soldiers everywhere ostensibly to collect the money, he arrested those who were of military age and sold them on the understanding that none of them should be liberated within twenty years." Strabo, the Greek geographer who lived at Rome near the time, tells us that 36,000 men survived, 8,000 of whom, capable of bearing arms, were sold, and thus "peace was kept as far as the highest parts of the passes."

Augustus's victory over the mountain tribes was commemorated by a trophy in the form of a three-storied tower whose ruins—restored only in 1934—still overlook the blue waters of the Mediterranean at La Turbie (the name is a corruption of Latin Tropaeum) near the summit of the Roman coast-road above Monaco, now a part of Napoleon's *Grande Corniche*. Its weatherbeaten inscription names forty-eight tribes then subjugated, while eight others are known from a smaller trophy set up at Susa on the Mt. Genèvre Route. Augustus further boasts on the famous *Monumentum Ancyranum*, lettered in Greek and Latin on the walls of a ruined temple at Angora in Anatolia, now the capital of the Turkish Republic, that "the war brought injury to none." Yet he had caused thousands to be slain and thousands more to be driven into slavery, all because they had fought the good fight of freedom.

By the close of the war the founder of

the Empire held both sides of the Alps, and he and his successors erected provinces to the north, expanding Roman power eventually from the North to the Black Seas. Only one monarch since, Charlemagne (768–814), has controlled the entire chain, for not even Napoleon gained all the eastern section. To-day the Alps are shared by six nations—Italians, French, Swiss, Germans, Austrians and Jugo-Slavs.

The cultural activity thus started by Augustus was even more remarkable than the conquest—the gradual Romanization of a vast area, a process which continued to near the close of the empire. Yet more, for that concerns ancient history only; for there was started a movement which lasted on through the medieval period down to the fifteenth century, during which the basis of the states of modern Europe was being laid. This was Augustus's unwitting gift to the modern world.

The conduits of this cultural movement were the Alpine roads which Augustus and his successors built to connect Italy with the north. Along these highways in the valleys below flourishing towns arose. To-day most of the important towns as far north as the Rhine and Danube are on Roman sites. In Switzerland alone nearly every large town is on a Roman or Celtic base.

But many of these towns, important in antiquity, have had a different history. Thus Concordia, Altinum and Aquileia in Northeast Italy, the starting places of roads over the Alps, are now mere fishing hamlets. North of the Alps Carnuntum on the Danube, certainly one of the oldest towns in Europe, in prehistoric times being in part control of the Baltic amber-trade, is now a heap of ruins, while Vienna just to the west, once a Roman camp, famed as the spot where Rome's greatest emperor, Marcus Aurelius the philosopher on the throne, died, is now a great metropolis. Sirmium on the Save, one of the four proud capitals of the empire in Diocletian's tetrarchy, is now only the wretched hamlet of Mitrovica in Jugo-Slavia, so named from its cloister of St. Demetrius.

Curiously the Romans from the time of Augustus onward instituted no new routes across the Alps, but were content to improve the ancient trails long before used by Celts and their prehistoric predecessors. In all Augustus built some eight roads along these ancient trails; along the Riviera from Genoa west; over the Mt. Genèvre, a restoration by his prefect Cottius of an older road built in 77 B.C. by Pompey the Great; the Little St. Bernard, similarly a restoration of the Gracchan road built in 122 B.C., and so the oldest in the Alps; the Brenner from Verona as far as Trent; the Ploecken route from Aquileia to Trent; the Birnbaumerwald road from Aquileia to Oberlaibach on the Save, later extended as the "Pannonian Highway" to Carnuntum on the Danube; and probably those over the Maloja and Julier connecting the Val Bregaglia in Italy and Coire in the Engadine.

Later emperors repaved these roads or built anew over other ancient trails. Thus Claudius in the first century constructed a road from Venetia through the Valsugana to the Brenner and beyond over the Reschen-Scheideck and Fern Passes to the Danube, and another over the Great St. Bernard from Aosta to Martigny on the Upper Rhone. The Severi between 195 and 215 built the first military road across the Brenner and Scharntz Passes from Trent to Innsbruck and on to Augsburg in Germany.

There are remains of these Roman roads all over the Alps where they have not been covered by modern turnpikes. In the Austrian Alps especially I have frequently seen the sign *Roemer Strasse* near the present highways. There are inscriptions on rock-walls and countless milestones. There are ruins of refuges,

notably a large one 216 by 60 feet, dating from the Later Empire, on the summit of the Little St. Bernard, discovered in 1837 by a party of English tourists, and another still larger, 200 feet square, found more recently three quarters of a mile beyond. A ruined *mansio* has also been found on the summit of the Great St. Bernard along with the remains of a temple of Jupiter—the latter the highest in the Roman Empire. There are many rock-cuttings against wind and snow, one, 200 feet long and 10 feet wide, being visible on the Great St. Bernard.

Stretches of ancient pavement, often with the ruts of chariots and carts cut deep into the stones, are numerous everywhere. Recently I followed two such above Radstadt on the northern side of the Radstaedter-Tauern Pass—one, now high above the modern road along the river, the other a mile long nearer the summit. Perhaps the best preserved remains are those between Haidenschaft and Oberlaibach on the Birnbaumerwald route, but certainly the most imposing are those just outside the hamlet of Altino, the beginning of the Via Claudia Augusta—now locally known as Agozzo. Here the pavement is twenty meters broad, but it gradually narrows to six, and in the foothills beyond to less.

Excellent examples of wheel-ruts are visible, five to six feet apart, on the top of the Julier. Above Tweng on the southern ascent of the Radstaedter-Tauern Pass are the best remains I have seen. Here, through a defile between the present highway and the river, is a pavement of glistening white marble in which the ruts are from four to five inches deep.

There is still another reminder of the ancient Alpine roads—the coins which have been found along them recalling the Roman custom of propitiating or thanking the local god for a safe transit. The monks of the Great St. Bernard have garnered over 1,600 such coins in the monastery museum, which date from 150 B. C. to the barbarian invasions in the fifth century. On the summit of the Julier in a hole at the foot of one of the two so-called Julier columns—Roman or Celtic in origin—a mass of copper coins has been found whose dates span the four centuries from Augustus to Constantius II. The most curious cache of all, however, was on top of the St. Theodule, a pass over two miles high leading from the Italian Val Tournanche to Zermatt, which I crossed in 1929. A maid from the Old Hospice in 1895 found in the ice a hoard of 54 coins dating from the time of Nerva to that of Theodosius the Great, a period of 300 years. As there never has been a road over this pass ancient or modern, such a find is hard to explain. Perhaps a few intrepid merchants dared the glaciers as smugglers do to-day, and left the coins in gratitude.

But we must not confuse these Alpine roads with the great turnpikes running straight to their goals over hills and valleys which we are accustomed to associate with the Romans—the greatest of road-builders. Of such turnpikes we need mention only one, the oldest and at the same time the model of all later ones, the famous *Via Appia* built in 312 B. C. by the blind censor Appius Claudius from Rome to Capua and later extended to Brindisi on the Adriatic. For that road has no peer for longevity. Four hundred years later the poet Statius still called it "Queen of Roads," and after another four hundred years, long after the barbarian invasions, Procopius, the court historian of Justinian's reign, says it was still in good repair, the surface blocks "having neither separated at all at the joints, nor has any one of the stones been worn or reduced in thickness, nay they have not even lost any of their polish." We have only to add that now, nearly fourteen centuries later, parts of this ancient road, especially in the vicinity of the catacombs of Rome and for a few miles further south, are still in use!

Will any of our concrete roads, racked by frost and heavy automobile trucks, last a fraction of the time?

The Alpine sections were far simpler than this and, after all, merely connecting links between the great highways far below. Nevertheless, they formed integral parts of the network of roads which once radiated all over Western and Southern Europe, and far into Asia and Africa.

The difficulty of crossing such mountain roads was of course then far greater than that which confronts travelers in the Alps to-day. Strabo mentions avalanches, layers of ice and roads along dizzy cliffs. In the fourth century Claudian, the last of the classical Roman poets, mentions "the awful paths where many a man has frozen to death, engulfed beneath vast masses of snow along with carts and oxen, where sometimes the entire mountain top plunges down in an avalanche of snow." His contemporary, the historian Ammianus, has left us a vivid account of his own descent of the Italian side of the Mt. Genèvre route above Susa. He speaks of steepness, overhanging rocks, and how in spring men, beasts and carts may all be engulfed in crevasses, the only remedy being to tie the wagons together and have men and oxen hold them back from behind. To avoid slippery ice he says wooden stakes were driven into the safest parts as guide-posts!

No wonder, then, that the Romans felt an aversion to the Alps. Their interest remained always practical, for the mountains were merely obstacles to be overcome in their expansion. Only merchants, officials and soldiers crossed them and never for pleasure, for the Romans never developed any sentimental interest in their scenery, inhabitants, languages, customs, flora or fauna. The story is often told how the greatest of the Romans, Julius Caesar, once while crossing the Mt. Genèvre to his army in Gaul composed an essay on "Analogy" in his curtained litter quite oblivious of the scenery! Such a story is merely typical of the Roman character.

Nevertheless the Romans overcame their dislike enough to build roads over most of the major passes yet in use today. Thus of the seven over the western Alps they knew all except the Mt. Cenis and Simplon; of the nine over the central Alps all except the St. Gotthard, Lukmanier and Stelvio; of the six over the eastern Alps they seem to have known all. This gives us a total of seventeen major passes out of twenty-three now in use. And they knew about as many minor ones as well. This seems a small number if compared with the great array of passes, both major and minor, now in use, of which the *Britannica* lists 518 throughout the Great Divide.

Throughout the Middle Ages—that indeterminate period of over a thousand years from the passing of Rome to the bloom of the Renaissance, or, perhaps, to the crisis of the Reformation—the old Roman roads over the Alpine passes were still used. In fact, we have records of very few new routes from that period, and all these were in the Western Alps.

Thus we first hear of the Mt. Cenis in a document of 731, and we know that its hospice, one of the oldest medieval ones in the Alps, was founded by Louis le Débonnaire or his son early in the next century. The St. Gotthard, one of the grandest of all, leading from Bellinzona in Italy to the Lake of Lucerne, was known to the Romans as far as Andermatt beyond the summit, but their way further north was barred by the Schoellenen Gorge through whose perpendicular walls of granite the brawling Reuss descends. Not until the chasm could be spanned by a bridge was it possible to reach the northern exit of the pass, and the first "Teufelsbruecke" was not built till around the year 1200, a hundred feet above the abyss. Lastly, the Lukmanier, after the Maloja the lowest and easiest pass from Switzerland

to Italy, is known from the records of its famous abbey at Disentis from 776, and the first recorded transit was that of the Holy Roman emperor Otto I, the Great, in the winter of 964–5. It is indeed a matter of wonder that throughout the medieval period so few new routes were opened and so few of the Roman roads were kept in repair. All sorts of reasons for this have been adduced—such as the division of authority among local powers, each responsible for its own section only, and lack of capital. But probably the main reason is to be found in the lack of labor to replace the Roman slaves. A recent historian has said that not one Holy Roman emperor imitated his pagan predecessors, the Caesars, either by building a new road or improving any of the old ones which they had inherited!

What had happened? We know that in the gradual dissolution of the Roman Empire after the death of Constantine the Great in 337 trade everywhere waned, for with the spread of Christianity religion usurped commerce as the chief interest of the Middle Ages. This change was of course reflected in the Alps as everywhere else. Now the merchants of an earlier day were replaced by pilgrims and ecclesiastics on the way to and from Rome, "the threshold of the Apostles."

The first of these medieval pilgrims to wander over the Alps were Saxons of England near the close of the seventh century. The first "English" itinerary describes the return journey from Rome of Sigeric, Archbishop of Canterbury, over the Great St. Bernard in 990—the most important itinerary since the Bordeaux-Jerusalem one composed six and one half centuries earlier. Icelandic pilgrims followed the Saxons around the year 1000. Thus we have an account of a journey from Schleswig to Rome and Palestine and return over the Great St. Bernard by Nicholas of Seemundarson, abbot of Thingeyrar in Iceland, written after his return from a three-years' pilgrimage made in 1151–1154. But what has been described more justly as the first Alpine "Guidebook" of the Middle Ages is the *Annales* of Albert of Stade, which describes his pilgrimage in 1236 from Germany over the Mt. Cenis to Rome to visit Pope Gregory IX. For the return journey the routes over the Brenner and St. Gotthard are described, with alternate ones over the Great St. Bernard and Septimer—five passes in all.

The most popular passes in the Middle Ages were the Great St. Bernard in the west and the Brenner in the east. Between 774–801 Charlemagne crossed the Great St. Bernard certainly twice, and perhaps six more times. In the eleventh century Pope Leo IX crossed the Alps eight times, and four were over this pass. It remained the chief western pass for all manner of men—merchants, soldiers, ambassadors, church dignitaries, emperors and popes, while the Brenner played a similar rôle in the eastern Alps. Thus out of seventy-two transits by German kings between 960 and 1250, forty-three were over the Brenner.

That the medieval traveler faced much the same difficulties and dangers in crossing the Alps as his pagan predecessor is shown by three contemporary descriptions of transits of the Mt. Cenis and Great St. Bernard in the eleventh and twelfth centuries. These dangers, apart from weather conditions, were the lack of food and refuges and, above all, the presence of robbers. Christian hospices, however, gradually replaced the Roman *mansiones* everywhere. Many of these have been restored or rebuilt, and so have survived to our time.

Perhaps the oldest Christian hospice was the one which formerly stood on the summit of the Septimer, a pass leading from Bivio on the Julier route in Switzerland to Casaccia in Italy. From its earliest mention in 831 it is known from documents for nearly a millennium. Abandoned in the tenth century, it was rebuilt around the turn of the eleventh, and again in 1542, and the latter one con-

tinued down to 1778. To-day even the site is difficult to identify, as I found in the summer of 1929. In fact, no Alpine pass has suffered such a woeful eclipse as the Septimer. From the ninth to the sixteenth century, it was one of the chief passes leading from the Upper Rhone to Lombardy, crossed by many pilgrims, merchants and German emperors with their armies. To-day its lonely trail is overgrown with shrubbery and almost forgotten, as it is now traversed only by a few pedestrians who use it as a short cut over the longer Maloja-Julier route near-by.

Of all medieval Alpine hospices none has greater fame than the two founded by St. Bernard, "the Apostle of the Alps," which after various restorations still stand on the summits of the passes which bear his name. We know all too little of this courageous archdeacon of Aosta. We know he was born at Menthon, where his ancestral castle still stands above the famous spa of Haute-Savoie. Even the room is still shown from whose window tradition has Bernard leap rather than marry the beautiful bride whom his father had selected for him—the event which sent him into the arms of the church. But even the date of his birth is contested. The one thousandth anniversary of the traditional date was celebrated by an encyclical of the present Pope Pius XI in 1923, in which he is named "protector of Alpine climbers," to which hob-nailed fraternity His Holiness belonged in his youth, when, in 1899, he discovered the "Ratti" route up Monte Rosa from Macugnaga. But now it is usual to push the date forward nearly a century, placing his death in 1081 instead of 1007, and the founding of the hospices between 1045 and 1049.

The Little St. Bernard hospice, for centuries controlled by the brothers of the Great St. Bernard, but now by the religious and military Order of Saints Maurice and Lazarus, has extended hospitality to needy travelers for centuries past. To-day some 15,000 travelers, mostly work-people from Italy, are said to cross the pass each summer and the refuge is kept open during the winter like its sister on the Great St. Bernard, though only the rector and a couple of servants are left with one or two dogs to carry on the work of rescue.

A visit to the loftier Great St. Bernard hospice is far more interesting. An abbey was founded at Bourg-St.-Pierre, eight miles below the summit on the Swiss descent, early in the ninth century. It was destroyed in the following century by marauding Saracens, who had their headquarters on the summit, perhaps in the ruins of the Roman refuge there. Though it was soon rebuilt its importance waned with the building of the hospice above.

The present building dates from the middle of the sixteenth century and its church from 1686. Besides the church it contains quarters for the prior and brothers, sixty beds for wayfarers, refectory, library of some 2,000 books, mostly gifts of travelers, and a museum of natural history, mineralogy and all sorts of Roman antiquities picked up on the pass. In 1898 a large annex, connected by a covered overhead passage, was built directly across the road with seventy beds. In 1925 it was converted into a hotel and restaurant, where all travelers, except those *sans resources*, must stay. Latterly those who arrive by autobus must pass on, in conformity with the ancient idea of a refuge for foot travelers.

I have most pleasant memories of a night which I spent here in August, 1912. I had walked up the Swiss side and was drenched by a storm of sleet encountered near the summit. Many other guests had already arrived by bus, and after a plain supper we all assembled in the cozy library on the second floor, which was apparently the only other heated room in the monastery. For our night's enter-

tainment we were expected to leave a gratuity in a box in the church simply marked *offrandes pour l'hospice.* It is a sad commentary on the ways of tourists that while perhaps 30,000 travelers crossed the pass each season, only a fraction of the upkeep of the hospice was defrayed by such donations. That is why the brothers turned the annex into a hotel, where ordinary tariffs are paid. On a second visit, fifteen years later, I was, therefore, courteously refused lodging at the monastery after the brother who had answered the bell found I was not without resources.

In the romantic novelty of a sojourn at such a height and in such solitude, one is apt to forget how dreary life must be for the brave little band of a dozen monks through the nearly nine months of the year when the hospice is practically inaccessible. Then the few wayfarers are poor, the cold is intense, the snow at times reaches above the second story windows—as dated lines drawn on the walls indicate—and blizzards buffet the summit. The brothers begin their work of rescue at eighteen or nineteen, but rarely finish their vow to remain fifteen years. Broken in health they descend to the dependency at Martigny, and there pass the remainder of their lives.

For, after the Fourth Cantoniera of Santa Maria on the Stelvio route, which is forty-six feet higher, the Great St. Bernard hospice, 8,114 feet high, is the loftiest all-year-round habitation in Europe. The higher Hotel Ferdinandshoehe on the summit of the Stelvio, 9,045 feet high, the Payerhuette, a climber's refuge high up on the side of the Ortler, 9,908 feet high, and the inn recently erected on the Jungfraujoch, 11,340 feet, the highest in the world, are only open in summer. In some years one can not reach the monastery till the middle of July because of the deep snow.

The monks in their work of rescuing travelers in distress are aided by their famous dogs, whose keen scent and endurance make them valuable in tracking those lost in the snow, and in bringing them first aid in the form of brandy. As the breed died out some years ago, Newfoundland dogs are used now. If a body is retrieved it is brought to the tiny morgue at the monastery, and there wrapped in a linen shroud and laid on a table. Here it remains until a second one replaces it, when it is stood upright against the wall with others, a custom common to many monastic orders. Because of the cold dissolution is very slow, and thus the dead man's friends can recognize the body long afterwards. Finally the bones are laid away, in what for lack of a better word, may be called a cemetery. But any real burial here is impossible amid the rocks which cover the summit.

In modern times the Alps have played an ever increasing rôle in war and commerce and, more recently, also in sightseeing. The latter is true of the last century during which splendid highways have been built across all the main passes, and since 1900 automobiling over them for pleasure has become very common.

There have been many historic transits of the Alps by armies in the last four centuries, and here above the clouds many heroic struggles for the possession of the pass-routes have taken place, culminating in those of the World War, when Italians and Austrians thus fought in the Eastern Alps. From a great number of military transits I shall mention only three of the more spectacular, one in the early sixteenth century and the other two three centuries later around the turn of the nineteenth.

The first important military transit in the modern era was that of the youthful Francis I, who with an army of 20,000 men and 75 cannon crossed three passes of the western Alps from Grenoble to

Italy in three days of August, 1515—the Col de Vars, Pas de la Reysolle and Col de l'Argentière. This was prior to the "moonlight" battle of Marignano in the following September, where the French arquebus was victorious over the pikes of the Swiss. Francis's experiences recall those of Hannibal, for he also had to follow bypaths never before crossed by an army and to blast the rocks. He had to swing his guns from rock to rock, and finally his cavalry vanguard swooped down upon the Papal troops so suddenly that the leader of the latter, Colonna, afterwards made prisoner, asked if they had descended from the clouds!

In 1799 and 1800, respectively, occurred two remarkable military transits, those of Suvarov and Napoleon. In September, 1799, the gigantic Russian field-marshall—he was six feet and eleven inches tall—when seventy years of age crossed the St. Gotthard on his return from North Italy where he had been fighting the French revolutionary troops. In the Schoellenen Gorge on the Swiss descent occurred one of the most terrific battles in Alpine history between his men and the French who barred the way, a struggle lasting four days and ending in the retreat of the latter. The battle is commemorated by a granite cross thirty-six feet high and a Russian inscription cut into the rock-wall above the present *Teufelsbruecke,* where the struggle took place.

Napoleon's passage of the Great St. Bernard with 36,000 men in 1800 is, perhaps, the most famous in modern times, though a good deal of its fame seems fictitious. During the Italian campaigns of 1798 and 1799 French and Austrian troops had repeatedly crossed the pass, and in the latter year the Austrians were unable to dislodge a garrison of 180 Frenchmen then quartered in the hospice on the summit. The next spring Napoleon sent his army across *en échelon* during the week of May 15 to 21, and then followed in person, starting from Martigny on the Rhone before dawn of the twentieth.

Painters have pictured his crossing the Alpine snows at the head of his troops fully caparisoned and riding a dashing charger. Nothing could be further from the truth, for he wore his usual grey surtout and was seated upon a mule in the rear of his last regiment! Moreover, he had only three companions, his aide Duroc, his secretary Bourrienne and a local peasant guide, with the latter of whom he whiled away the tedium of the journey in conversation, and to whom he later gave a house and field to facilitate his marriage. He lunched at Bourg-St. Pierre at the mouth of the Valsorey Gorge eight miles below the summit. The tiny inn there has ever since borne the grandiloquent title of *Hotel du Déjeuner de Napoléon Premier.* On one of my walks over the pass I had the honor of sitting in the armchair in which the First Consul sat, and listening to the tradition that Napoleon's meal consisted of eggs, toast and coffee like my own!

On reaching the summit he stopped at the hospice only long enough to thank the monks for their entertaining his troops. In gratitude he promised he would place them in charge of the hospice on the neighboring Simplon over which he had already planned a military highway, and to this day both hospices are under the Augustinian Order. He glissaded on the Italian descent like any tourist of to-day, and spent the night at the hamlet of Étroubles, having covered forty miles astride his mule that day! On the following day he continued on to Aosta and Bard in preparation for his victory to be won at Marengo on the fourteenth of June.

Such transits as those described followed the old Roman-medieval roads. Before Napoleon little road-building in the modern sense was known in the Alps. To be successful such construction re-

quired the use of powder to break the rock, and it is curious how slowly blasting-powder came into use. We first hear of "powder-blasts" toward the end of the Middle Ages in connection with "Kunter's Way," a two-mile section of the Brenner built in the fourteenth century. Again in the fifteenth, between 1481 and 1483, Duke Sigmund of Tyrol built another section of the same pass-route by splitting the rock with "fire, sulphur, and iron." But powder on an extensive scale was first employed in 1697 in the construction of a rock-hewn road through the Berguen Gorge of the Albula. And we hear little more of its use for a century thereafter.

It was Napoleon, then, who, during his temporary hold on Switzerland and North Italy, gave the modern impetus to Alpine road-building, an impetus comparable with that of Augustus eighteen centuries before. For, during his transit of the Great St. Bernard just described, he experienced the difficulties of transporting an army over a lofty pass without a good road. His artillery was then as badly impeded by natural difficulties in ascending the Valsorey Gorge—up which his cannon had to be dragged encased in hollow logs—as Hannibal's elephants had been.

Between 1800 and 1810 Napoleon had four military highways constructed over the western Alps: the coast-road from Nice to Genoa, including the *Grande Corniche* to Mentone, and those over the Mt. Genèvre, Mt. Cenis and Simplon. Curiously he did not build one over the Great St. Bernard, where a modern road was not completed on the Swiss side till 1893, and on the Italian, including the connecting link over the top, till 1905. He also began a road over the Col de l'Argentière, and planned another over the lofty Umbrail far to the east, which was not finished till three years after his death on St. Helena, and was restored between 1899 and 1901. Before the 1830's were over many other pass-roads had been built—notably those over the Simplon, Julier, San Bernardino, St. Gotthard and Stelvio.

In the modern period only a few major pass-routes have been opened, even fewer than in the medieval period preceding. Perhaps the best example of such a new route is that over the Stelvio in the Central Alps. Here the Austrian Government constructed a military road in 1820–1825 as a feeder into the Umbrail route then being built. Its construction was a continuous struggle with snow and ice at a height theretofore open only to expert climbers, a truly astonishing work of engineering skill.

Railways over the passes began with that across the Semmering in Austria, built 1845–1854. The seventy-fifth anniversary of the first official transit by the then youthful Franz Josef was celebrated on April 17, 1929. It was followed by a railway over the Brenner in 1867, and that by the boldest and most spectacular mountain-railway in the world, the one built over the St. Gotthard between 1872 and 1882. For this railway has 324 bridges and 80 tunnels—including the great one under the pass to be mentioned—three of which are spiral in form on the Swiss ascent and four on the Italian.

With mountain-railways began the piercing of the passes by tunnels. The first one beneath the Semmering is only 1,581 yards long—a little less than a mile. To-day five great tunnels cut the Alps, three through the main divide and two wholly within Switzerland and Austria, respectively. The oldest of these is the so-called Mt. Cenis Tunnel, which runs beneath the Col de Fréjus, some seventeen miles southwest of the Mt. Cenis Pass, and connects Modane in France with Bardonnechia in Italy—a distance of eight miles with the approaches. It took fourteen years to build it, 1857–1870, and the engineering was

so accurate that the borings, begun simultaneously at either end, joined almost exactly in the center.

The St. Gotthard Tunnel, connecting Goeschenen in the Schoellenen Gorge in Switzerland with Airolo in Italy, is nine and a quarter miles long, and required ten years, 1872–1881, to complete. The longest railway tunnel in the world is still the Simplon, over thirteen miles in length with its approaches. It has parallel tubes, built in 1898–1906 and 1912–1922, respectively, for one-way traffic. The culminating point of the tunnel is 4,270 feet below Napoleon's highway over the pass, and the encircling mountain crest above rises nearly 3,000 feet higher yet!

The longest tunnel wholly within Switzerland is the Loetschberg, nine miles long, beneath the Gastern Valley and Loetschen Pass on the long road from Brigue to Frutigen, opened in 1911 after four and one-half years of work; while the longest in Austria pierces the Arlberg, connecting St. Anton and Langen on the route from Innsbruck in the Tyrol, six and one-third miles long, constructed in 1880–1884.

Nor should we omit the short tunnel up the Jungfrau built 1896–1912. This ascends through the interior of the mountain far above the snow-line at a maximum gradient of one in four to Jungfraujoch, the highest railway station in the world—a unique triumph of Swiss engineering. But one should not make the mistake of thinking that the railway has done away with the famous climb to the top of the mountain. For it still takes nearly four hours in good weather to cross the Jungfrau Glacier far below the inn, and then to climb the steep ice-covered knife-edge beyond to the top. But fatigue and the danger are forgotten in the magnificent panorama over the Bernese Oberland and the Alps of Valais, a view stretching from Mont Blanc to Monte Rosa, and including the Matterhorn and many of the best-known peaks of Switzerland.

The automobile has long since found its way over all the major passes, and soon it will have its own tunnel, one under Mont Blanc, the monarch of European mountains! Back in 1854 a railway tunnel was proposed beneath between Chamonix in France and Courmayeur in Italy to shorten the journey from Genoa to Turin. But in 1934 the plan was changed to a motor tunnel, with double tubes, like our Holland Tunnel under the Hudson, to connect Chamonix with Entrèves near Courmayeur, a distance of eight or nine miles long, and this may soon be a reality. The pressing need of an automobile route of this kind between France and Italy is evident from the fact that out of six existing Alpine roads across the frontier of 230 miles between them only one—the Riviera route—is open in winter.

This brief sketch of the story of Alpine roads has shown that the use of most of the major pass-routes has been continuous from prehistoric times to the present. Long before the advent of man in the Alpine solitudes, nature had marked out just where such routes could go. Their story, then, is merely the gradual use man has made of the passes throughout the ages. Their number and location were fixed for all time by the natural configuration of the Alpine chain.

NEW EVIDENCE (?) FOR "EXTRA-SENSORY PERCEPTION"[1]

By Professor CHESTER E. KELLOGG
McGILL UNIVERSITY

Among the many factors making for the progress of science in recent years, one of note has been the general recognition of the importance of science in promoting human welfare. This recognition has been fostered by a number of able writers, gifted with the ability to make abstruse topics plain to the general reader. Creative men of science who can write with such literary grace as a Huxley or a James are rare indeed. So to such middlemen of science as Clendening, Kaempffert, Wiggam, Slossons, de Kruif, etc., both research men, who require public support, and the public, whose well-being is aided by science, may well be grateful.

Naturally, occasional mistakes are to be expected. Discoveries which appear to promise great benefits will sometimes give rise to propaganda for application before possible bad consequences have been fully considered, as, for instance, was the case when the drug scopolamin was first discovered, and the alleviation of suffering in childbirth had to be weighed against the risks of still birth. But on the whole, public interest in and encouragement of scientific research is surely an asset, and, just as surely, this interest can not be had if the results of research are set forth only in the difficult technical phraseology of the professional journals.

Yet, grateful as scientists are to those who make science known to the world, and however inured they may be to the occasional blunders of untrained eagerness, many psychologists have been startled by the contributions of a recent recruit to the ranks of these educators, Professor Ernest Hunter Wright, chairman of the Department of English Literature at Columbia University. Although systematic investigation of the problem is hardly more than begun, he has decided, on the basis of some preliminary studies partially reported by Professor J. B. Rhine, of Duke University, and without taking account of the negative results of other researches published both before and since those of Rhine, that the existence of the capacities termed clairvoyance and telepathy has been established beyond all doubt. Accordingly, he has published two articles[2] giving an exposition of the supposed proofs, and some entertaining theoretical speculations. These utterances, coming from a high ranking instructor in one of our leading universities and therefore supposedly authoritative, have received a good deal of publicity.

Concerning the theories, no comment need be made at present. We would suggest that they be held in reserve until such time as it may be known whether there is anything to explain. For, while Professor Rhine's experiments have yielded some interesting results, it is quite certain that neither he nor any of his followers has so far given proof of the existence of either clairvoyance or telepathy. It is unfortunate, but true, that it is easy to utter sweeping generalities, on the basis of a few striking cases, which will appeal to the general public

[1] A critique of Professor J. B. Rhine's studies, in reply to the articles by Professor E. H. Wright, published in *Harper's* for November and December, 1936.

[2] "The Case for Telepathy," *Harper's*, November, 1936; "The Nature of Telepathy," *Harper's*, December, 1936.

and secure adherents, and which, once implanted in the public mind, will "flourish like a tree planted by the rivers of water," and can only be eradicated with extreme difficulty. For disproof, like genuine proof, has to be founded on thought rather than on emotion.

Since Dr. Rhine's reports have led to investigations in many other institutions, it might seem unnecessary to prick the bubble, as the truth eventually will out and the craze subside. But meanwhile the public is being misled, the energies of young men and women in their most vital years of professional training are being diverted into a side-issue, and funds expended that might instead support research into problems of real importance for human welfare. This has gone so far that a new *Journal of Parapsychology* has been founded. On all counts, the request of the editors, in their preface to the first issue, that their studies be given searching criticism should not go unheeded.

I

My first direct acquaintance with the more scientific approach to "parapsychological" problems came when, as a member of Hugo Muensterberg's graduate seminar at Harvard in the season 1913–1914, I heard his comments on his visits to the home of little Beulah Miller, in Warren, Rhode Island. The clue to her apparently astounding telepathic ability turned out to be her response to involuntary movements on the part of others in the family, movements made when they were following her counting, or running through the letters of the alphabet to spell out the desired word.[3]

A few years later appeared the report by John Edgar Coover on his investigations of psychic research at Stanford, a notable example of painstaking, thorough research, and exact treatment of numerical data. One section of the volume reports on experiments in card guessing, and so is of special interest for comparison with recent work. No justification for belief in any sort of occult powers was found.[4]

One more study ante-Rhinum is perhaps worth recalling—the test conducted by Sir Oliver Lodge, with the aid of the British Broadcasting Commission. Sufficient comment is supplied by the heading of one of the newspaper clippings in my files—"20,000 REPLIES, MOSTLY, WRONG, IN PSYCHIC TEST Letters Reveal Amusing Variety of Bad Guesses —A Few Pretty Near Right," etc. That performance more or less dampened the ardor of the public for this particular brand of mystification until it was revived by Rhine, whose studies appear to the uninitiated to have reinstated scientific method in this field. That this was his intention may be taken for granted.

For the purpose of a definite target, and without going into minute detail, extracts from the general remarks on the first page of Professor Wright's second article will serve:

> the evidence is the outcome of more than a hundred thousand tests, simple but purely scientific, made by Professor Rhine and his associates in Duke University. . . . The . . . various tests in question were all made with a pack of cards, twenty-five in number. Each card bore on its face one of five different designs—a circle, a rectangle, a star, a cross, or a set of wavy lines—and each of these designs appeared on five of the cards in the pack. Anyone who took the test . . . was simply asked to name as many of the cards as he could without looking at them and without other sensory access to them. In pure chance of course he would average one card right in every five, or five in every twenty-five; and as he continued, twenty in every hundred, two hundred in every thousand, and so on. The idea was simply to see whether anyone, or any group of persons, could steadily name enough of the cards right to show that something more than mere chance was at work. About half of the tests were for clairvoyance and the other half were for telepathy.

[3] *Cf.* Muensterberg, "Psychology and Social Sanity," New York, 1914.

[4] Coover, "Experiments in Psychical Research at Leland Stanford Junior University," Stanford University, 1917.

The result of the experiment was seen to be amazing. About a score of men and women were discovered who could regularly name so many of the cards correctly that there was not one chance in many a million million of their having done their feats by luck or accident; [etc., etc.].

First, we must correct errors in these basic statements. One of the distinctive features of Rhine's studies of telepathy has been the ruling out of the possibility of clairvoyance by having the experimenter merely think of the designs, without using either the cards or any other objective representation of them. As the relative frequencies are not subject to exact control by this method, the chances are variable; and since no records in detail have been given out, it is impossible at present to say exactly what they may have been. The average chances set forth apply then, strictly, only to the tests of clairvoyance. Furthermore, they apply only in the long run; deviations from the theoretical average can not be considered as of much importance in the case of a small number of scores. This point will perhaps carry greater weight in the phraseology of an impartial writer. I turn to page 413 of "A College Algebra," by Henry Burchard Fine, Boston, 1905:

The fraction a/m, which we have called the probability of an event, means nothing so far as the actual outcome of a single trial, or a small number of trials, of the event is concerned. But it does indicate the frequency with which the event would occur in the long run, that is, in the course of an indefinitely long series of trials.

Thus, if one try the experiment of throwing a die a very great number of times, say a thousand times, he will find that as the number of throws increases, the ratio of the number of times that ace turns up to the total number of throws approaches the value $\frac{1}{6}$ more and more closely.

Fine is speaking of trials in which the probability remains constant, and every trial is independent of every other one. Now, as will be shown below, this is not true of the trials making up a run through the pack in Rhine's work, so only the runs can be considered as giving scores to be compared with chance. Accordingly, the reference to so and so many thousand trials means a great exaggeration of the amount of evidence obtained; a hundred thousand trials yield only four thousand scores, all told, and these must be separated into groups according to the special methods used. But even the four thousand have not been reported. Less than three hundred and fifty runs are listed in the article in which Professor Rhine sets forth his results as a foundation for later research.[5]

Again, while it is true that some of the experiments were carried out at a distance, in a large part of the clairvoyance tests, the cards were both handled and seen (face down) by the persons tested, and, as will appear, this sensory access contributed remarkably towards the more successful series of runs.

Finally, as to the score or so of men and women with such remarkable ability *regularly* to name the cards, etc. Here it seems that enthusiasm has outrun the facts. At any rate, no consistently high series of scores, obtained under conditions for which the chances can be calculated, has yet been published.

II

The whole argument rests on a supposed difference between actual results of the tests and those to be expected by chance, so it is clearly essential to make sure of estimating the chances correctly. Professor Wright speaks of the average scores by chance. Not all chance scores are the same, however, as any one who ever took part in a game of chance knows full well. Pure chance will give some high and some low scores. How are the proportions of these to be estimated?

[5] *Journal of Abnormal and Social Psychology*, 31: 216–228, 1936.

For this purpose Coover used the binomial theorem, of which many of our readers doubtless retain some vague and perhaps not wholly affectionate memories, as its very great importance is rarely explained to high-school students. The terms of the binomial expansion, as will be shown, give the appropriate chances for the method of experiment followed by Coover. Rhine, however, modified the plan of experimentation in such a way as to increase the chances of extreme scores, both high and low, but used for calculation of chances, as an approximation to the binomial expansion, the normal probability curve, which underestimates the relative frequency of high scores by chance. So his estimates are doubly at fault.

In his experiments on card guessing, Coover used ordinary playing cards, omitting the face cards. The pack of forty cards was shuffled and cut before each single trial of a series, and guesses were scored as to correctness of color, suit and number, the chances of success being $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{10}$, respectively, and the expected distributions of scores given by the terms in the expansions of $(\frac{1}{2}+\frac{1}{2})^{40}$, $(\frac{1}{4}+\frac{3}{4})^{40}$, and $(\frac{1}{10}+\frac{9}{10})^{40}$. To show that this is correct, consider a very simple case, the guessing of color, with only three trials in a set. The drawings of the cards can be of four sorts—three black, two black and one red, one black and two red, three black. The chances of these four sorts are given by the terms of $(b+r)^3$, *i.e.,* $b^3+3b^2r+3\ br^2+r^3$. There are three different ways of getting two black and one red, or one black and two red, but only one way of getting either three black or three red. If there is no such thing as clairvoyance, so that the guesses are random, like the drawings of the cards, then the chances of the various possible guesses can be described in the same way, provided the person guessing has no bias in favor of one of the colors. Then the chances of the possible scores —0, 1, 2 and 3—can be obtained by finding the relative frequency of these scores given by scoring each of the eight different arrangements of three cards drawn—bbb, bbr, rbb, brr, etc.—against each of the eight different arrangements of three guesses. The frequencies from the sixty-four matchings are found to be 8, 24, 24, 8, as given, letting p stand for success and q for failure, by the terms of 64 $(q+p)^3$, p and q each having the numerical value $\frac{1}{2}$. The chances, instead of the frequencies, are given by the terms of $(q+p)^3$. Q. E. D.

Rhine desired to test for pure clairvoyance, ruling out telepathic influences arising from the experimenter's knowledge of the run of the cards and of the scores in the course of a set of trials. So he changed to shuffling the pack at the beginning of a set, running through the twenty-five trials possible with his special pack, and then scoring the record of the guesses against the arrangement of the pack. He did not realize that this method altered the chances. To prove that it does, consider another simple example—tests with small packs of six cards containing three groups of two similar items each. The binomial appropriate to this case for Coover's method of shuffling before each drawing is $(q+p)^6$, with p of numerical value $\frac{1}{3}$ and q $\frac{2}{3}$. Possible scores run from 0 to 6, and multiplying by 729, so as to give whole numbers—which amounts to setting down the theoretical frequencies for a series of 729 sets of six trials each, we have:

Scores	0	1	2	3	4	5	6
Frequencies	64	192	240	160	60	12	1

Rhine's method involves no drawings, as the pack is fixed, but only various arrangements of the given cards. For this special pack, there are 90 different arrangements, all equally likely to occur. As the person guessing is supposed to be

aware of the method used, his guesses can be expected to follow a similar plan, so the appropriate frequencies will be given by scoring any one of the possible arrangements against itself and all the rest. The result is:

Scores	0	1	2	3	4	5	6
Frequencies	10	24	27	16	12	0*	1

* No scores of 5, because if five match, all six must.

The reader can easily check up on this list by comparing with the arrangement *a a b b c c* various other positions of the letters, such as *a b c c a b,* which scores 1, *c a c b a b,* score 2, etc. To facilitate comparison with the binomial frequencies above, multiply those just given by 8.1, and take the nearest whole numbers, giving:

Scores	0	1	2	3	4	5	6
Frequencies	81	194	219	130	97	0	8

Both distributions average 2 hits, but what a difference in the proportion of extreme scores!

The binomial, then, underestimates the frequency of high scores. But Rhine does not use the binomial; he substitutes the normal probability curve—a symmetrical curve which is the limit approached by the binomial $(\frac{1}{2}+\frac{1}{2})^n$, as n increases without limit. It is also approached, though not so rapidly, by the binomial when the two fractions are unequal, provided neither is extremely small, but in this case, the approach is only for scores not very far from the average. Rhine, however, does not restrict his use of this approximation to very large numbers of trials; he uses it whatever number he happens to be evaluating, and he pays attention chiefly to high scores, for which the normal curve estimate is never accurate. For our simple sample pack the normal frequencies would be

Scores	−2	−1	0	1	2	3	4	5	6
Frequencies	1	8	56	173	252	173	56	8	1

(one score of the 729 is left unaccounted for)

The absurdity of using a function which implies the existence of negative scores needs no argument. Rhine pays no attention either to the normal distribution as a whole or to his own score distributions, but merely adds up the hits of the runs in a series, and then evaluates the total, with reference to a normal curve supposedly approximating the binomial having the total number of trials as exponent. This is a very crude process and is clearly unjustifiable for evaluation of high scores, when these differ from the chance average more than the latter does from zero, for the occurrence of any such score reveals that the distribution can not be normal. The illustration also shows that, as remarked above, the normal curve estimates of high scores fall short of those given by the binomial, which in turn fall short in comparison with the valid distribution. For this special case the totals of the scores higher than 3 are 65, 73 and 105, respectively.

The same sort of difference holds good in general, though of course the exact figures depend upon the make-up of the pack in question. For Rhine's pack of five sets of five, there are over 623 trillions of different arrangements, so that a solution by tabulation and comparison is beyond human capacity. A solution by higher mathematical methods has been completed this season at McGill, and will be published in a more technical article.

The simple illustrative problem can be used also for the promised demonstration of the linkage between the single trials of a run through the pack, when the pack is shuffled only at the beginning of the run. For the six-card pack, the chance of success in guessing on the first trial is $3\times\frac{1}{3}\times\frac{1}{3}$, or $\frac{1}{3}$. (The chance of the first card being an *a* is $\frac{1}{3}$, the chance of the first guess being an *a* similarly $\frac{1}{3}$, so the chance of a score on *a* is $\frac{1}{3}\times\frac{1}{3}$. As *b* and *c* count similarly, the total chance

of a score is three times as great.) The chance of success on the second trial, after success on the first, is $(\frac{1}{5})^2 + 2(\frac{2}{5})^2$, or 9/25, *i.e.*, 0.36, instead of 0.333. . . . The chance of success on the second trial, after failure on the first, is only $(\frac{1}{5} \times \frac{2}{5}) + (\frac{2}{5} \times \frac{1}{5}) + (\frac{2}{5})^2$, or 8/25, *i.e.*, 0.32. So the trials of a run are not independent and the chances are not constant, as is required for the use of the binomial theorem. The same kind of calculations can of course be made for Rhine's E S P packs, and with the same sort of relations between the results.

To conclude this section of the argument, the chances for a few scores, as estimated by the three methods, will be set down for comparison. (1) is actually used by Rhine as an approximation to (2), which he believes to be theoretically correct. (1) is more convenient because tables of the normal curve are available. But (3) is the valid series for his method of conducting the tests.

Score	(1) Normal Curve $\frac{1}{\sqrt{8\pi}} e^{-\frac{x^2}{8}}$	(2) Binomial $(\frac{4}{5}+\frac{1}{5})^{25}$	(3) Matchings in Permutations of E S P pack
1	.0270	.0236	.0255
3	.1210	.1358	.1369
5	.1995	.1960	.1937
7	.1210	.1108	.1145
8	.0648	.0623	.0636
9	.0270	.0294	.0312
10	.0088	.0118	.0135
11	.0022	.0040	.0042
12	.00044	.00117	.00152
15	.0000007	.0000115	.0000192

These calculations are for scores from a single run. When several runs are combined to give a total score, the discrepancy increases the larger the number of runs in question, and especially for high scores. Unfortunately, while (1) is easily adjusted for application with any number of trials, (2) and (3) have to be recalculated completely for each number of runs combined. This requires considerable labor for (2), a prohibitive amount for (3), so there is no method available for evaluating merely the total score of a small number of runs. A crude estimate of the significance of a series of scores can be made when their fluctuation—not merely their total—is known. The only completely satisfactory test requires a large number of actual scores, whose distribution can be compared with the chance series. The decimals listed in (3)—the complete series, that is to say—have simply to be multiplied by the total number of scores in question, to give the chance frequencies needed.

III

If Dr. Rhine had published complete reports of the scores from his experiments, his error in estimating the chances would not be so misleading. But he has selected for comment only the more fortunate results, a policy which is quite indefensible in any case, and worse still when the significance of the items reported is so much exaggerated.

The unusual always attracts attention, and is easily made a source of mystery. Once, many years ago, my hand at bridge consisted of all the spades in the pack, an event to be expected only once in 779,737,580,160 times. But as the same is true of every other hand that can be mentioned, there was really no occasion for great wonder, although, of course, not all hands are equally noticeable and desirable.

Perhaps, in very truth, no event ever recurs in its entirety. Even to our limited insight, it is evident that the more completely any complex event is described, the less likely is what we have observed to be experienced again. But

though every occurrence may be thus unique, many of them are in terms of human interests and needs substantially equivalent, while others stand out as especially desirable or undesirable. Thus, in card guessing, a perfect score is no more of a rarity than any specified one of the many possible ways of getting an average score. In Rhine's clairvoyance tests, whatever one's score may be, the chance of getting that particular score in exactly that way was only one out of 623 trillions. But we pay attention only to the scores, conveniently forgetting the low ones, accepting the ordinary run at or near the average as due to chance, and marvelling at the high ones.

So, when Dr. Rhine says that one of his students has made a total score that could be expected to occur by chance only once in a hundred quintillion times, the natural tendency is to believe the score could not have been obtained by chance at all, that it must be explained by some hidden power, etc., etc., without inquiring what this same student may have scored on other occasions, and to what extent the peculiarities of the experimental procedure may have contributed. Even the skeptical scientist, reading such a statement, may be somewhat intrigued before he pauses to reflect and look over the data. The evidence which Rhine evaluates as a series of 1,625 trials is really a set of only 65 runs, with scores ranging from 1 to 12, average 7.4, which does not seem to reveal any very consistent or marked capacity. The series was conducted by the "down through" method, *i.e.*, the cards were shuffled and cut and then not handled further until the check-up, so that the pack was in sight during the guessing, but not the separate cards, the subject endeavoring to name the cards from the top down. The shuffling was frequently done by the subject himself, the cut always by Dr. Rhine. Rhine says that the best scoring was done with the last five cards, at the bottom, and next best with the five at the top. (No figures stated.) Was there perhaps some sensory clue to the identity of cards in these places, definite enough to raise the average two points above the pure chance level, so that, except for that discrepancy, the scores vary as if merely due to chance? Some such conclusion is suggested by tabulation of the scores.

Keeping this possibility in mind, it is interesting to turn to another selection reported from the work of the same subject, in which, after the pack was shuffled, he held it face down, tried to name the top card, removed it and tried the next, etc., the scoring being done at the close, as with the "down through" series. In this work, the scores average 9.5 instead of 7.4. Is this better clairvoyance or a better opportunity for slight sensory clues to improve the guesses? The separate run scores fluctuate as widely as those of the other series, but at a higher level—from 4 to 15.

Another series, also from the work of this subject, is most helpful towards supplying the answer. For this series, testing "clairvoyance at a distance"—the experimenter and subject working at various distances in different college buildings—rules out any sensory clues. The average score is 7.5, a trifle above that of the "down through" series, but the scores range all the way from 0 to 13 and are in general more scattered than those of the other series, and so much more suggestive of pure guesswork. In Rhine's report, the series is subdivided into four groups. A formal calculation of their significance—taking into account the amount of fluctuation in the scores, which Rhine ignores—shows that Group A remains significant, Group B is just above the borderline, and Groups C and D are well within the limits of ordinary chance accepted by scientists as not de-

manding special investigation and explanation. Taking all the groups together, the results are positive and somewhat significant, perhaps sufficiently so to warrant further study of the problem. This is the strongest claim that can be justified by this evidence, especially in view of the many hundreds of scores not reported. The usual methods of calculating significance are intended only for evaluation of random samples, and it must always be borne in mind, in reading Rhine, that the scores listed were not selected impartially, as random samples, representative of a mass of evidence too great to be reported as a whole. They are special series picked out as seeming to make a case for the favored theory.

Perhaps the objections to use of selected evidence can be made clearer by a comparison of the present problem with the more familiar one of the interpretation of scores in intelligence tests or other examinations. Although we may still be unable to agree upon an exact definition of intelligence or scholarship, there is no doubt that these desirable attributes exist. A small degree of apparent success in such a test as the Army Alpha, first used in examining recruits in 1917 and 1918, can be got by pure luck. An illiterate, marking the pages at random, may perhaps appear to earn four or five points, but any considerable score depends upon real ability. The average college student scores in the neighborhood of a hundred and fifty points, and all scores of which any use is made are so far from chance that a single test is a reliable measure. Teachers' marks in school and college are, it must be confessed, far from precise measures, but even so, high marks do usually imply high scholarship. In Rhine's experiments, the very existence of the capacity tested for is in question, and all the single scores that actually do occur can occur by chance. Isolated scores, then, have little importance. Conclusions can be validly based only upon the relative frequencies of the high and low scores obtained, and so *all* that are obtained must be taken into account.

The essence of this method of study lies in the opportunity for comparison of actual with mere chance results, by restricting the calls to items for which chances can be calculated. No valid comparison is possible unless either all evidence, or if that is too unwieldy, a sample taken entirely without bias, is compared with theory. In such an experiment, as in any game of chance, when only a comparatively small number of scores is secured from each subject, some will score high, some low, the great majority at or near average, merely by chance. If the entire distribution of scores is large enough to make an adequate sample, and is found to conform, within reasonable limits (not to go into technical methods of evaluation), to the chance series, then there is no positive evidence, and therefore no more excuse to select a high score than a low one as having any special meaning. Both, in proper proportions, are to be expected by chance. Lifting out of their context the scores of the more fortunate subjects, and then evaluating them, without regard to the existence of all the rest, as if they were a random sample, and thus deducing the existence of some special capacity, begs the whole question at issue. Any genuine factor apart from chance would show up in a departure of the total distribution from the chance series. This given, examination of the data might reveal whether such factor is more or less general in its influence or confined mainly to a few subjects.

If any one were found to secure *consistently* high scores, a further study of his abilities could be advocated regardless of the results of others. But no such person has ever been found.

Rhine has given no distributions of his

scores as a whole or any large groups of them. He seems to have been so firmly convinced of the existence of "extra-sensory perception" before he began research that he has never realized such a general comparison might be desirable. Instead, he has simply selected some of the subjects who were most fortunate in the early part of his work and given them further tests. If these had been handled impartially, all would be well. But the fact that these subjects were picked out as promising dominates all their later tests. When good scoring, on the average, continues, well and good. When it does not, when their later results do not pan out, they are said to have lost their former ability, although no proof, on the basis of an adequate random sample of their scores, has been offered to show that they ever had any ability. The reader is given no opportunity to judge of this fairly, because complete results are not reported, even for the selected subjects. When for a time they do well, Rhine sets down the scores, over-evaluates them by his customary technique and draws conclusions favorable to his theory. When they fail, that is regrettable, but it has no influence on his conclusions. The special ability is temporarily exhausted or has vanished; its prior reality is never questioned. The poor series are not listed, and their very existence is only incidentally mentioned. Rhine does not go so far as to assume that the supposed capacities vary from hour to hour; good series are reported in full, zero scores and all. He is entirely sincere, and does nothing that from his standpoint would appear to be falsification of evidence. He simply does not realize that such selection of the better series does not conform to the requirements of his chosen method of research, but assumes the truth of the conclusion he is trying to prove.

E.g., a short series—only eight runs, average 10.1—is cited as proof for "telepathy at a distance" (the series mentioned as the "Junaluska Series"), with experimenter and subject, two of the women students, 250 miles apart. Note that this is a telepathy test and can not be evaluated in accordance with the chances calculated for the clairvoyance work. There could, obviously, be no score below zero or above 25. For the rest, the only information made available concerning the possibilities is the series of scores actually obtained. They range from 2 to 19. When due allowance is made for this fluctuation, the series is found not to be significant, even on the assumption that the chance average is only 5. In fact, supposing that the subject's true average is likewise 5, she might, judging from this set of scores, be expected to obtain, by chance, an average as high as or higher than 10.1 in about one case in every forty-two, in the long run. Other results of this subject are even less promising, and are mentioned only to justify Rhine's belief that this series did not involve collusion between the two students, since in other cases, when good scores were particularly desired, she did not get them. But then why assume that she was "telepathic" at all?

All the statistical tests so far mentioned have been *ex post facto*, concerned with the problem, given such and such results, how significant are they? There is a familiar rule, simple and straightforward, for the guidance of the experimenter in the course of a research, in deciding whether a sample set of values is adequately representative. . . . From time to time, calculate the average of all the results so far recorded. Continue the gathering of data until additional values make no appreciable difference in the average. Then the average is valid for the given conditions of experiment. . . . Rhine's procedure with his selected subjects is directly opposed to this rule. He

rejects all series of scores that would modify the favorable averages.

Certain other results are reported from telepathy tests in the laboratory. Although the scores are higher on the whole than those in any of the other series, the possibilities of error in the records, and the uncertainty of the chances involved, except that it is quite clear that they were much higher than those in the clairvoyance tests, preclude giving these results any great weight. Apparently, only a partial record was kept, that of the calls made by the subject, in some of the runs two rooms away from the experimenter, with the doors open, but with an electric fan going so as to prevent any involuntary whispering of the experimenter from being heard by the subject. The experimenter had to try to think of the various designs as nearly as possible five times each in a run, but with no written plan to follow, give buzzer signals to call the attention of the subject for each trial, record the responses as heard, or supposed to be heard, check them if correct. Judge the effect on the scores of the almost inevitable tendency, especially in a laboratory so full of faith in E S P, to give the subject the benefit of the doubt in any trial involving some difficulty in hearing or in memory, and the great likelihood of illusions in hearing, the hearing of one call as a different one, especially when the observer gets excited in the course of a good run, and so hears what is desired instead of what is really uttered, yet with not the slightest realization of the possibility of a mistake. The much greater ease in following a lecture or play in one's own language has often been explained as due not so much to differences in understanding what is actually heard, as to the readiness to fill in gaps in auditory stimulation and, as far as conscious experience goes, hear the whole. In such a case, expectation is guided by the context, in line with the familiar usages of the native tongue. In the telepathy tests, success may breed success, in the record, by creating such an attitude of optimism that the observer-experimenter will strongly tend to hear the name of the symbol he has just been "sending." Again, if experimenter and subject happen to have thought preferences in favor of the same one or two of the designs, scores will be increased regardless of any mutual influence. Any experimenter in such work will also tend to form more or less definite order-habits. This possibility was recognized, and precautions taken to counteract it. Cross-checks, applied to *other* series, show these precautions were on the whole successful. At any rate, habits did not become so established that similar plans were used in *immediate* succession. But many of the different arrangements of the designs, that would occur in the shuffling of a pack, would almost certainly not be included among the plans chosen consciously. Some might seem too systematic, *e.g.*, aaaaa bbbbb, etc.; aaaaa bcd bcd, etc., . . . eeeee. On the other hand, others with no apparent plan would give no ready means of keeping to the equal frequencies desired. If such helter-skelter arrangements are avoided, the range of possibilities is reduced; if not, there is more scope for symbol preferences which may be correlated with those of the subject. Rhine, as a means of controlling frequencies, coached his experimenters to plan by groups of five, which leads most naturally to five sets of one each of the five designs, thus very much reducing the number of different arrangements. (From 623 trillions down to less than 25 billions, subject to further reduction by avoidances, etc.) This extreme he seems to have tried to prevent, but the measures taken for the purpose are not such as to result in anything like the total possibilities of shuffling. There has been no mention of any attempt to

keep secret the instructions given for the conduct of the tests. It would be strange if students interested in the work did not sometimes discuss various possible arrangements of the symbols. However that may be, subjects would surely tend to follow somewhat the same general sort of procedure as the experimenters—which means a marked increase in the chances of high scores. As the subjects were informed of their success at the ends of the runs, adoption of plans of the type used by the particular experimenter would be favored. Skill could thus be developed just as it is in various familiar card games. Indeed, a good player might adjust to this experimental situation almost immediately.

Without specific records of the exact sequences of the designs chosen by the experimenter and the corresponding calls of the subject, no worthwhile estimates of the chances can be made. No such records have been published. They were kept, apparently, for some parts of the work, but not for the series cited and partially listed in Rhine's article, as important evidence. This evidence accordingly is valueless.

If it is really important to test for *pure* telepathy, which precludes any proper estimation of chances in advance, then surely complete records should be made, so that calculations can be worked out from the results. Of course a written record is open to the same objection as the use of cards—the opportunity for clairvoyance. So dictagraph records should be taken. Then all the arrangements actually occurring in the records of each experimenter and subject should be listed and classified, and the chance score frequencies tabulated for comparison with those actually obtained.

To sum up: Professor Rhine's argument for extra-sensory perception rests upon the differences between scores obtained and those to be expected merely by chance. It has been shown (1) re clairvoyance:

(a) that he greatly underestimates the chances for high scores;

(b) that he pays no attention to the internal inconsistency of the results;

(c) that he draws conclusions from selected portions of the evidence, in a way that assumes the truth of the very theory he wishes to prove;

(d) that among the selected series, those giving the highest scores also offer the greatest opportunity for sensory clues to the identity of the cards.

(2) re telepathy: that the chances in this part of the research are unknown, so the supposed evidence can not be used.

The complete data have not been published, even in summary form, so as to permit of an independent verdict. The whole research is therefore quite inconclusive.

THE NEW DOGMATISM

By Dr. FRANCIS B. SUMNER

PROFESSOR OF BIOLOGY, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA, LA JOLLA, CALIFORNIA

MANY of us professional men of science have long since demolished, to our own satisfaction, most of what currently passes as "religion," and have even called in question the very existence of "theology" as a legitimate object of inquiry. For lack of any real evidence to support their claims, these are subjects which must perforce be taught dogmatically and authoritatively. But science, on the contrary . . . ! We have all stressed this invidious comparison, and I think on the whole that we have been justified in doing so. But the difference is not such an absolute one as many have been led to suppose. To the man in the street nearly all science is taught dogmatically. He accepts it from authorities whom he is led to believe that he can trust. Some of this matter, to be sure, appeals to him as inherently reasonable. Much of it, on the other hand, is downright unintelligible to him, or it may even challenge his common-sense.

So much for the "man in the street." What about those of us who spend part of our time indoors—say in laboratories and libraries and classrooms? William Graham Sumner, whose opinion of the intelligence of the "masses" was none too high, remarked sagely that outside of our own specialties we all belong to the masses. Outside of these specialties, we take our science, for the most part, on authority. It is a different kind of authority, to be sure, from that upon which a devout peasant accepts the miracles wrought by his saints' bones. Our direct sources of information are men who have earned their right to be trusted. And more important yet, they can often show us the evidence for their statements, or at least they can tell us how—in theory, at least—we can find this evidence for ourselves. However, as science expands, and the sphere of each specialist contracts, the proportion of our knowledge which we individually get on authority rapidly increases, and the proportion which we get by observation, experiment and constructive thinking rapidly diminishes.

Furthermore, the day has nearly passed when we even go to our authorities for their factual "results." For the most part it is their "conclusions" which we carry away. Outside of the ever-narrowing fields in which we ourselves are authorities, the things which we assimilate from our scientific environment are interpretations often many steps removed from the crude data. Much of the time, we do not even know what these crude data are like. Nor would they mean anything to us could we see them. And so, not only do we depend more and more upon authority for our scientific information, but this information, when it reaches us, arrives in the form of abstractions to a large degree divested of living reality.

A worshipper, repeating the "Apostles' Creed," expresses his belief in the "resurrection of the body." A student, reciting in a chemistry class, tells the professor that the "atomic number" of sodium is 11. I do not wish to make too much of this comparison. All I contend for is the probability that to many students "atomic number" is just as much of a dogma as "resurrection of the body," and just as little capable of being translated into terms of human experience. As to the professor—well,

there are professors and professors of course. But any kind of an instructor in chemistry will tell the student in a few words just what the expression atomic number "means." The number of positive charges on the nucleus of the atom —what could be simpler? And so, I doubt not, could any bright Sunday-school teacher given verbal account of the resurrection of the body.

The conception of atomic number finds its ultimate justification, of course, in a vast array of observational evidence. But how many of us—aside from one particular brand of chemist or physicist — actually have first-hand knowledge of this evidence, or are even in a position to follow it understandingly if it were furnished us by visual demonstration?

A further perplexity has been added to this whole situation by the increasing application of mathematics to the so-called "fundamental" sciences. Much of this is not the sort of mathematics which the ordinarily well-educated science student from one of our better colleges carries away with him. It is a realm of mental activity into which relatively few persons in the world are qualified to enter. However, unless we fulfil these drastic requirements, we are altogether unable, it would seem, to follow the reasoning upon which some of the most notable scientific generalizations of the day are based. Worse yet, we are even denied the privilege of understanding in any real sense what these generalizations mean. And *a fortiori*, we are denied every right to criticize them. Be that as it may, we do not seem to be absolved thereby from the duty of accepting these generalizations and of rendering homage to those mighty minds which have been able to develop them.

The name of Einstein has become almost a household word throughout the civilized world, and the picturesque head of this mathematical genius is probably as familiar to the public to-day as that of most other contemporary world figures. It is far from my purpose here to question the greatness of Einstein. I am quite willing to accept the appraisement of his fellow specialists on that score. Yet how many persons have the faintest idea what the name of Einstein stands for in the history of science? How many persons—indeed, how many scientists—are even capable of learning this, try as hard as they may? Any well-informed person now has a fairly accurate idea of what the name of Darwin stands for. Or at least he can be taught. And so, in general, with the major results of modern biology. A few hours of well-directed reading will convey to any really educated person the chief discoveries of the Morgan school regarding the physical basis of heredity.

But this question of relativity! That is a horse of another color. Many courageous attempts have been made in recent years—some, indeed, in the popular press—to expound relativity in non-mathematical language. They usually start out with the already familiar idea of the relativity of motion. For a while, the reader follows eagerly. At last he is going to be enlightened! Then he loses the trail, sometimes suddenly with the introduction of some new and unintelligible train of thought, sometimes gradually, after sinking deeper and deeper into what seems to him a bog of paradoxes and *non-sequiturs*. At least this has been, for the most part, the experience of the present writer in reading with care a considerable number of these attempted elucidations.

Any person of average education and brain-power is doubtless capable of attaining some degree of verbal "understanding" of this subject. And even a newspaper column-writer may be able to convey such a purely verbal "explanation" to readers less informed than himself. But all the reader is likely to re-

ceive from such sources is a vague, sketchy notion of the kind of problems which the relativist is trying to tackle, along with some bewildering paradoxes which are offered him as unavoidable consequences of the theory. At best he can get only dim and tantalizing glimpses of its real substance.

All this is not, of course, offered as criticism of the theory of relativity. The chief difficulty obviously lies in the attempt to grapple with certain highly abstruse problems by persons whose mental preparation has not qualified them for the task. But an almost equal difficulty, I believe, lies in the methods which have been resorted to by the theory's expositors.

In general, the illustrative "experiments" by which the principles of relativity are justified to the reader are purely imaginary ones, involving such things as the observer's moving through space at the velocity of light or moving at an accelerated motion, corresponding to the acceleration of gravity, or involving his ability to read another man's clock or measuring rod, while one or both of the parties are traveling at these furious speeds. And if some ignoramus of a biologist should express mild surprise at this to him unfamiliar method of solving scientific problems, he would forthwith be silenced by reference to certain equations by which Einstein *et al.* have *proved* all these things! And so it goes. These revolutionary doctrines can only be understood—and by the same token, can only be criticized—by persons equipped with a mathematical technique which very few living persons can master.

This does not seem to relieve us, however, of the obligation to accept these doctrines. And they are being accepted with all the authority of a gospel, often, I doubt not, by persons who have no more real understanding of them than the present writer. Why, then, should I presume to withhold my own acceptance? Who am I to dispute the conclusions of the master minds of the century? My answer is that I am not disputing them; I freely grant their probable truth. But I contend that neither I nor any other person can really believe that which one finds to be by its very nature unintelligible to him.

I recall, in this connection, a passage from a catechism, a copy of which fell into my hands many years ago. To the question (quoted, I am sure, with substantial accuracy), "After the priest hath blessed the bread and wine, and converted them into the flesh and blood of our Savior, what remains of the bread and wine?", the young believer is taught to respond "Only its properties." I can see little difference between "belief" of this sort and the avowal of belief in anything else which is equally meaningless to the person concerned.

A few other aspects of the "new physics" are equally relevant at this point in our discussion. The now well-known antinomy regarding the electron—assertedly both a particle and a wave—is a case in point. True, we can not conceive of a thing's being both a particle and a wave at the same time. But what we can *conceive* apparently has no bearing on the situation. Modern physics seems to have definitely abandoned the notion that we must be provided with mechanical models of what happens in the universe. If equations can be found which express the relations in question—if, in the present case, they show how "the particle- and wave-pictures are merely two aspects of the same reality"—that should be enough to satisfy us.

To those of us who use mathematics merely to express quantitative relations among *things*, such a solution of the difficulty is altogether puzzling. A disembodied equation may be highly interesting and valuable when we are concerned with pure mathematics, but it hardly

serves as a substitute for a description when we are concerned with phenomena in the physical world. At least this is true for the non-mathematical mind. To an unsophisticated naturalist I fear that this argument that a thing may have the properties of a wave and a particle at the same time is too strongly reminiscent of some of the old-time theological arguments for the doctrine of the "Trinity."

All this, while granting the high probability that the equations which these scholars have devised are rigidly exact in every particular. The important question before us is whether at long last our conceivable space-time models of natural phenomena are to be wholly replaced by a series of equations expressing relations among unknowables. This is the avowed ideal of some of those who are writing in the name of modern physics. "An ideal shines in front of us," says Eddington, "far ahead perhaps but irresistible, that the whole of our knowledge of the physical world may be unified into a single science which will perhaps be expressed in terms of geometrical or quasi-geometrical conceptions. Why not? All the knowledge is derived from measurements made with various instruments."[1] And Jeans writes: "The essential fact is simply that *all* the pictures which science now draws of nature, and which alone seem capable of according with observational fact are *mathematical* pictures."[2] This despite Jean's avowal in another place that recent science, in contrast with nineteenth-century science, "is no longer in flat contradiction with our intuitions and the experiences of everyday life." When the goal set by these mathematicians is attained, real science will be the property of a small esoteric group, while the rest of us, it would seem, will have to content ourselves with crude and misleading visual symbols of reality.

[1] "The Nature of the Physical World," p. 136.

[2] "The Mysterious Universe," p. 150.

There are some, I doubt not, who look forward to such a situation with entire complacency. Those of us, however, who follow the "natural history" sciences must find the prospect decidedly disconcerting. And, being human, we can hardly fail to resent the strong tinge of arrogance which seems to be implied in such a forecast. We have long been accustomed to invidious comparisons between the "exact" sciences and those which, not being "exact," are scarcely to be regarded as sciences at all. Even some of our biologists seem disposed to concede that only the precisely quantitative part of their domain deserves the name of science. Science is science, it appears, only in so far as it is capable of mathematical expression. That such a definition would exclude some of the greatest advances in scientific knowledge does not seem to disturb those who continue to repeat it.

Psychologically speaking, it is not difficult to understand how an accomplished mathematician might readily fall into an attitude of arrogance toward those of us who work with other tools. He is master of a technique which few of us can handle —perhaps, we may add, that few of us could ever learn to handle with much proficiency. He is quite aware of our utter dependence upon him for the solutions of many of our problems. And he realizes, too, how one-sided this dependence is. While we must appeal to him at rather frequent intervals for help which he alone can give us, he has no real need of anything which we may be in a position to furnish.

Personally, I stand in considerable awe of these men who can fill their pages with differential equations. They have mental powers of a sort which I could never hope to attain. It is true that I stand in almost equal awe of the man who can play six simultaneous games of chess with a blindfold over his eyes, or even the man who can play a single masterly game with the board before him. He too

has mental powers which seem stupendous in comparison with my own. However, I can not tolerate this sense of inferiority very long. I recall that the really great chess-players are not often known for any other mental achievements, and I try to persuade myself that some of our most accomplished mathematicians might prove to be "all thumbs" if they were rash enough to enter the field of experimental biology. There is an even chance, too, that this pollicality might not be entirely on the neuro-motor level!

Whether or not the word "science" will ever come to be restricted to the quantitative aspect of natural phenomena I should not be rash enough to predict. If such a restriction (or shall we say perversion?) of the meaning of this word were ever generally accepted, we should have to find another word for that vastly greater field of knowledge not yet reduced—perhaps never to be reduced—to mathematical terms. Here would belong the work of such men as Harvey and Pasteur and Lyell and Darwin, and—despite his ratios—of Mendel. And here will continue to belong a large majority of the most interesting, important and influential contributions to human knowledge, and the output of many of our most original minds. Some enterprising journal of the future might start a contest for the best name by which to call all this!

However, to return from our digression, if we can not follow the mathematical reasoning of these neo-physicists, we can at least understand in a measure some of the conclusions to which their reasoning has led them. And here at times they come into rather violent conflict with the common-sense of mankind. Common-sense, to be sure, has long been abandoned as a safe guide to truth. But it is relevant to point out this conflict in a discussion of the relations of science to current thinking. The wave-particle paradox has already been referred to. Once more, we have been told that if one traveled with the speed of light, he could make a tour of the universe without aging, though coming back to a world which had grown old during his absence. And again it would seem that our old nineteenth-century notions about infinite time are unfounded. The universe started *de novo* only a few thousands of millions of years ago (not a very impressive figure to an astronomer) and has been expanding at a terrific speed ever since. To Eddington it seems reasonable to believe that the earth, of all among the near-infinitude of heavenly bodies, is probably the only home of living beings; also that the present universe is the unique product of creative energy, having not only a beginning but an end. "I would feel more content," he says, "that the universe should accomplish some great scheme of evolution and, having achieved whatever may be achieved, lapse back into chaotic changelessness, than that its purpose should be banalized by continual repetition."[3] Jeans mentions rather casually that "the number of particles—electrons and protons—in the universe is of the order of 10^{79}."[4] The same writer has expressed his oft-quoted conviction that "the universe appears to have been designed by a pure mathematician." Verily we all make our gods after our own images!

The diameter of an electron is said to be only a fifty-thousandth that of an atom. By its very nature it is forever beyond the range of human vision. Nevertheless, most of the popular expositions of twentieth century physics speak with the same nonchalance of manipulating individual electrons and observing their behavior as a biologist speaks of his experiments and observations upon protozoa or bacteria. We learn, for example, that "Heisenberg

[3] "Nature of the Physical World," p. 86.

[4] "The New Background of Science," p. 264.

succeeded in showing that one may choose *either* to determine the place of a flying electron *or* to ascertain its speed with precision, but that there can be no experiment which will fix location and velocity *at once* with the maximum accuracy."[5] I venture to assert that no popular expositor of one of the "inexact" sciences could talk that way and get away with it!

It happens that these speculations of Heisenberg's and some others have been seized upon with avidity by various persons having metaphysical or theological axes to grind. And this number includes more than one scientist of real prominence. One line of argument seems to run somewhat as follows: *If* we were able to see an electron, it would be impossible, for certain theoretical reasons, to determine both its velocity and its position at the same time. Therefore, the electron, at any given moment, has either a definite velocity or a definite position, but does not possess both of these. Therefore, the principle of "determinism" or "causality" does not apply to the ultra-microscopic world, but only—in a purely statistical sense—to the macroscopic world. And other reasons are given for believing that events in the ultra-microscopic world "just happen," that, for example, one atom out of a million in a mass of radium elects to disintegrate without prompting from any source excepting its own sweet will.[6] Thus "spontaneity" and "free will" come back upon the scene, stamped with the guarantee of modern science!

Merely to repeat these various assertions is surely not to refute them. Indeed, I should not be so reckless as to attempt to refute them. But many of us have probably formed rather decided opinions as to their reasonableness. And on the principle of judging a tree by its fruits, we may have come to mistrust the methods followed by those who tell us some of these things. Or at least, we may have lapsed from our former attitude of humble acquiescence.

Nor does it seem to be true that all these master minds of modern physical science agree with one another. Those who have followed, even casually, the publicity which has attended the recent developments in physics and astronomy know that the field is beset by controversies. And among the controversial questions have been some of the most vital ones—whether, for example, the universe is finite or infinite or whether or not it is rapidly expanding. Millikan has argued that the "cosmic rays" represent a by-product of the creation of matter in space. Jeans and others have been equally convinced that they originate from the destruction of matter. Some writers argue for an indeterminacy which is absolute; and assure us that causality has been banished from science; others argue that this indeterminacy is merely relative to our knowledge. And our elementary units of light and electricity—are they particles which move as waves, or waves which manifest some of the attributes of particles? Or are they simply disembodied equations which scorn representation by any visual models whatever?

Without presuming to question for a moment the mental profundity of some of these exponents of the "new physics," nor the vast importance of their actual discoveries in this field, one can not help wondering whether the up-to-the-minute publicity so widely given to their more speculative utterances through the lay press or through popular volumes of their own authorship is not considerably impairing the status of

[5] Reichenbach, "Atom and Cosmos," p. 262.

[6] At least one writer has seriously contended that the mysterious genetic "mutations" of the biologist are similarly uncaused. We need scarcely point out the paralyzing effect of such doctrines as these on scientific progress.

science in the public mind. There would seem to be a vast inconsistency between the traditional notion of the man of science, with his uncompromising insistence on evidence and his lofty scorn of guesses and unproved assumptions, and the quasi-mystic who tells us all these strange things about space and time and infinity and who describes with such assurance the detailed intricacies of an infinitesimal world forever beyond the range of human observation. And this bewilderment of the layman is surely not lessened when he learns that these master minds are not always in agreement among themselves. Yet, curiously enough, this speculative and controversial part of recent physics appears to be stressed as much as any other one thing in current portrayals of scientific progress in the popular press. So far as the "general reader" is concerned, it would seem to be vastly better if the newspaper columnist would only gather his material from the teacher of elementary science instead of hovering around the notables who are engaged in extending its frontiers. But that sort of material would not, I presume, rate as "news."

It was long ago suggested that the growth of science would reach its limits through the unchecked increase of specialization. We should finally have an immense cluster of endlessly subdividing branches, each physiologically isolated from what remained—if anything—of the original organism. This is perhaps an unduly pessimistic forecast. But it does seem certain that an ever-smaller proportion of what we individually "know" will have the vivid reality of something immediately experienced, and an ever-increasing proportion will consist of abstractions and interpretations received from other persons.

However, all this is no reason to discourage the dissemination of knowledge regarding scientific discovery, so far as this is possible. It has long seemed to some of us that the "new physics" has been very largely unfortunate in its interpreters to the laity. Despite some exceptions, there has been altogether too much of what impresses one as "showing off"—too much parade of individual brilliancy and resort to whimsical analogies and startling paradoxes, and too little earnest attempt to make the reader really understand the matters on hand. What some of us would like to find is first of all a clear description of what the experimenter really does and sees, and *after that* an account of his theoretical interpretations. We are too apt to read about "bombarding the atom," "smashing the nucleus," "weighing the electron" and the like, with commonly but the faintest intimation of how all this is done and why these effects are inferred. As Swann pointedly remarks: "We say that we set up apparatus and measure the number of electrons going through a certain hole. We do no such thing. We make settings of certain electrical instruments, and we make readings of others. From our readings and settings we *calculate* these visions of electrons going through holes, and the like."[7] It is unfortunate that this realistic view-point is not more constantly kept in mind by the popular expositor of recent scientific developments, biological as well as physical. Since the foregoing article was submitted for publication, a highly interesting article by an English professor of astrophysics has appeared in the *Atlantic Monthly*.[8] It gratifies me to learn that there are among the physicists themselves some who "view with alarm" the current trends in popular exposition.

[7] "The Architecture of the Universe," pp. 175, 176.

[8] "Knowledge without Understanding," by Herbert Dingle, *Atlantic Monthly*, July, 1937.

THE DESTRUCTION OF "VERMIN"

By Dr. ALBERT M. REESE

PROFESSOR OF ZOOLOGY, WEST VIRGINIA UNIVERSITY

At their annual meetings, in December, 1936, both the American Society of Zoologists and the Ecological Society of America passed resolutions condemning the wholesale destruction of our wild animals in the so-called "vermin" control campaigns being waged in so many of our communities. The author was requested by the latter society to write two articles on the subject, for publication in The Scientific Monthly and in *Nature Magazine.*

We hear and read a great deal about "our vanishing wild life," but it is doubtful if the average reader realizes the part played in the vanishing process by the so-called "vermin or predator control" campaigns that are sweeping the country.

The term "vermin" is applied, chiefly by sportsmen and dealers in sportsmen's supplies, to those animals, without regard to their beauty, interest or value, which are *supposed* to be harmful to the few species that the sportsman himself wants to kill.

The term as used perhaps originated on the great hunting estates of Europe, where game wardens, often very "hard-boiled" individuals, were paid to protect their employers' game against human poachers and every other danger except the owner's firearms. Most absurd ideas of "vermin" sometimes obtained, as in the case of the warden who destroyed nightingales because, he said, they disturbed the sleep of the pheasants.

Perhaps no such extreme ideas are held in this country, but when more than 69,000 chipmunks are destroyed in a year in one state under the name of "vermin," we, who enjoy watching or making pets of this attractive little animal, wonder if the word "vermin" was not attached to the wrong mammal.

The live-stock interests are probably chiefly responsible for the war of extermination being waged, mainly by the U. S. Biological Survey, against the larger predators of the western states. In 1936, 1,115 wolves, 64,566 coyotes, 6,980 bobcats and lynxes, 287 mountain lions, 173 bears and 6 ocelots were destroyed. What effect this destruction will have on the numbers of destructive rodents in this area remains to be seen. The fur trade is said to be solidly against the policy of poisoning predators, believing that "the very existence of the domestic fur trade is threatened."

There are several groups of people who are interested in wild animals. The smallest, and, in most localities, nonexistent, group is composed of those who need the animals for food. The second and larger group includes those who make their living by collecting furs; this group is also lacking in most communities. A still larger group, found in practically all communities, comprises the sportsmen; in this group are also the manufacturers of the arms and ammunition used by the sportsmen.

By far the largest group of persons interested in wild life are those who enjoy watching and studying the live or scientifically mounted animals in the woods, fields and museums. We who belong to this universally distributed group can see no justice in allowing a smaller and generally well-to-do group to destroy, by the hundreds of thousands annually, many beautiful or interesting animals because they are thought, often

incorrectly, as we shall see, to diminish the numbers of a small group of *game* animals that the sportsmen want preserved so that they may be killed for sport.

To gain an idea of the kind and number of animals killed in these "vermin" control contests note the results for 1935 in an "Eastern State" as given in Publication No. 59 of the Emergency Conservation Committee.

Species	Number
Gray fox	1,700
Weasel	2,900
Wildcat	188
Mink	404
House cat	8,410
Crows	19,616
Kingfisher	1,546
Snakes	184,702
Carp	331
Rats and mice	115,016
Hawks	7,270
Owls	3,123
Waterdogs	14,571
Gars	462
Blackbirds	783
Sparrows	3,936
Turtles	21,566
Shite pokes	42
Ground squirrel	69,780
Eagles	4
Groundhog	1,203
Eggs (snake, crow, hawk and owl)	1,308
Terrapins	28,572
Starlings	19,186
Red squirrel	7,606
Total	514,225

Note that snakes, hawks, owls and eagles are destroyed as groups, apparently without regard to species.

Let us consider these four groups in turn. The order of snakes undoubtedly includes some species that are of little, if any, economic value to man, and few people would advocate the protection of the more dangerously poisonous ones; but to include, say, the house snake, the black snake and the bull snake in the "vermin" list because an occasional sportsman sees one of these familiar forms in the act of destroying the nest of some game bird is as unjust as it would be to kill all dogs because a sheep-killer is seen in a farming community. Yet in the above list 184,702 snakes were numbered.

The case of the hawks and owls is still worse, as a majority of the hawks and practically all the owls have been shown, by extensive studies of stomach contents and food pellets, to be highly beneficial as destroyers of rodent pests. In some communities only the hawks known to be more harmful than beneficial are permitted on the "vermin" lists, but this does little good, as few people know the species of hawks, especially at a distance or on the wing. To prove that this was true the following experiment was tried: seven well-mounted specimens of our *common* hawks were placed in a row, each specimen numbered; the eleven sportsmen present, all of them educated men, were asked to name, by numbers, the seven hawks; five of the eleven men failed to correctly name a single bird and only one named as many as five of the seven hawks. This experiment was tried on two other occasions, known to the writer, with similar results. Unless, then, a severe penalty be imposed for killing the wrong birds, it is obvious that the naming of certain hawks in a "vermin" campaign is little more than a gesture.

The establishment in 1934 of the Hawk Mountain Wild Life Sanctuary, on the Kittatinny Ridge, in the east-central part of Pennsylvania, was a grand stroke of conservation, as hawks of all sorts were there being slaughtered each year by the thousands, purely for sport.

The eagle case is somewhat similar to that of the hawks, since the average person can not tell the bald from the golden eagle until the former is mature and develops the white head- and tail-feathers.

The bald eagle, which was made our national emblem by act of Congress on June 20, 1782, is generally regarded as a harmless species; the case of the golden eagle is not so clear, but its rarity, in most regions, makes its possible occasional depredations of little importance.

It is thought an eagle can lift an object of its own weight, from 8 to 11 pounds. As a lamb averages from 7 to 8 pounds at birth an eagle *could* carry it off, for a short time after birth, and might kill it for a much longer period, even if it had grown too large to lift from the ground; but to believe that an eagle could carry an eight-year-old boy, weighing 50 pounds, up twenty feet before dropping him from fright, as has been reported, is asking too much of our credulity. In another case reported in West Virginia, the eagle, which measured some ten feet across, attacked a railroad worker and was finally killed after a desperate fight. On writing to the man, whose name and address were given in the paper, it was found that he had killed an eagle, but the account of the great size and savage attack were pure fiction.

As our magnificent national bird is largely a fish-eater and scavenger it is utterly inexcusable that it should be exterminated, and it is the writer's opinion that the golden eagle also should be protected in practically all parts of its range.

According to F. H. Dale[1] "The Golden Eagles are highly beneficial to agriculture in the sum-total of their activities and should not be destroyed as a species, although occasional individuals may require destruction because of lamb-killing habits."

In the same article Dale quotes a letter from the sporting page of the *San Francisco Chronicle* as follows:

. . . I use my airplane, which is a three-place biplane. I remove the left door so the gunner can shoot to the left. I have ribbons taped to the wires so they will not shoot into the propeller. . . . At times I am able to fly within 50 feet of the bird by getting behind and slightly over it. We are permitted to kill golden eagles but not the bald variety. . . . This is something new and I am in the business of taking passenger-hunters out. In an hour's time I usually cover 70 or 80 miles of territory. . . .

What chance does the eagle have in such a case? Dale says: "The five eagles seen by me, and said to have been killed or crippled from an airplane were all bald eagles"—another case where the protection of one species does little good when a similar species is unprotected.

An interesting pamphlet, "Save the Bald Eagle," is one of the many being distributed by the Emergency Conservation Committee, 734 Lexington Avenue, New York City.

Suppose it be assumed that the smaller predators, the "vermin" of the sportsmen, do destroy considerable numbers of birds that are desired as game. Does the destruction of these predators have a beneficial effect in increasing the numbers of game? The results of the investigations of Dr. Paul L. Errington and others in Wisconsin and Iowa on the quail population seem to give a negative answer to this question.

These field experiments were carried on during the years 1929 to 1934. It seemed to be shown that the carrying capacity of bob-whites for a given area depended upon the winter carrying capacity of that area. If there were too many birds at the end of the breeding season they were reduced to a fairly definite number by the end of the winter, depending largely on the food cover and escape cover of the area, with little apparent relationship to the number of predators. Errington says:[2]

I do not intend any statement of mine to mean that under no circumstances could predators have any influence upon quail populations. I make no pretense of knowing all there is to

[1] *The Condor*, September–October, 1936.

[2] *American Forests*, January, 1935.

know about the matter. Natural relationships are too complex to permit of any hard and fast generalities. But the data from five years work make it apparent, nevertheless, that the influence which differences in predator numbers may have had on the survival of quail populations studied has been so slight as to be unmeasurable. Certainly the importance of predator control in the management of the northern bob-white has been grossly overestimated, while a deplorable lack of attention has been given the manipulation of food, cover, and covey ranges. Indeed the public tendency has been to emphasize the negligible predator factor to the virtual exclusion of management measures that really count. . . .

Man himself, by means of his intelligence and modern hunting equipment, is about the only predator of which I know efficient enough to reduce bob-white populations much below the normal winter carrying capacity of the land.

An aspect of "vermin" destruction that is appreciated by but few persons other than trained naturalists is the possibility of upsetting the so-called "balance of nature" or the "web of life." As Grinnell says:[3]

The relationships which have been set up through the ages between wild birds, mammals, and plants, in fact between all forms of life, can not be disturbed unless we are willing to accept the consequences—and these may be exceedingly serious for us.

The possible results of the introduction of new species into a given territory are more generally appreciated than the destruction of an indigenous species.

J. R. Kinghorn, in a presidential address, "Faunal Problems," published in the *Australian Zoologist*, Volume V, Part 3, calls attention to the problem, among others, of the well-known rabbit pest of that country. Introduced by Governor King in 1791, the rabbits are now so numerous that it has been estimated that if they could be eradicated, "New South Wales alone could carry another 10,000,000 sheep." Although such a pest to agriculture there is another side to this question, as the pelts of rabbits were exported in 1926 to the value of over 4,000,000 pounds sterling and the carcasses brought in 3,000,000 pounds; about $35,000,000 is a considerable income to be derived from a waste product.

[3] Scientific Monthly, pp. 533–556, December, 1935.

Those who are advocating the extermination of our interesting pelicans because of their supposed destruction of fish might note a similar case quoted from Sir Arthur Thompson in Publication No. 1, page 16, of the Federation of Ontario Naturalists.

There is an Australian story that reads as if written for man's instruction. On certain Murray River swamps several species of cormorants used to swarm in thousands, but ruthless massacres, based on the supposition that cormorants were spoiling the fishing, reduced them to hundreds. But the fishing did not improve; it grew worse. It was then discovered that the cormorants fed largely upon crabs, eels, and some other creatures which devour the spawn and fry of the desirable fishes. Thus the ignorant massacre of the cormorants made for the impoverishment, not for the improvement of the fishing. The obvious moral is that man should get at the facts of the web of life before, not after, he has recourse to drastic measures of interference.

Now, the question is, What can be done to stop the slaughter? Perhaps the public will have to be educated until it can force the passage of necessary legislation. The most logical agents to secure this legislation would seem, perhaps, to be the state conservation commission and similar groups under other names.

But alas, of the twenty-seven commissions that replied, out of 36 that were questioned, nineteen expressed themselves in favor of "vermin" control campaigns.

According to a U. S. Biological Survey Bulletin, issued in 1935, 28 states pay bounties on certain birds or mammals or on both. One state, this year, will pay $40 to each group that kills more than a certain number of animals in its campaign. Various individuals and organizations are waging a strong war against this evil.

Conservation has suffered an irreparable loss in the recent death of Dr. William T. Hornaday.

The Emergency Conservation Committee deserves the support of all conservationists. That excellent popular journal, *Nature Magazine,* is a tireless and fearless advocate of conservation. The Federation of Woman's Clubs might be, perhaps is, a mighty force to secure legislation.

The American Society of Mammalogists, a few years ago, appointed a Special Committee on Predatory Mammal Control, with the well-known mammalogist, H. E. Anthony, as chairman. After careful investigation the committee made its report and made the following recommendations, which were adopted:

(1) That the Society strongly urges the Biological Survey that the use of poison as a control measure against predatory mammals be drastically curtailed, with the view of complete suspension of poisoning as soon as reasonably possible.

(2) That the Society deplores the propaganda of the Survey which is designed to unduly blacken the character of certain species of predatory mammals, giving only part of the facts and withholding the rest, propaganda which is educating the public to advocate destruction of wild life.

(3) That the Society asserts the claim of the great nature-loving public to a voice in the administration of our wild-life resources, and challenges the right of a federal organization, such as the Biological Survey, to consider only the interests of a very small minority, the livestock interests.

The attitude of trained naturalists towards wild-life destruction is seen in the following protest, issued, about two years ago, and signed by the heads of many of our greatest natural history institutions:

A PROTEST

WE, the undersigned, having taken cognizance of the fact that conditions operating for the destruction of American wild life are becoming increasingly intolerable, view with the gravest concern the present wholesale and largely indiscriminate use of poison at the hands of paid, and frequently irresponsible hunters, whereby it appears that the very existence of all carnivorous mammals, including those valuable species which constitute the chief check upon injurious rodents and are a vital element of our fauna, is imminently threatened over large areas. We therefore earnestly petition that this extensive program of poisoning operations be immediately abandoned, and that no extensive and general destruction of any form of wild life, by trapping or other means, be permitted in the name of expediency, without this course having first been abundantly proved as justifiable from an economic view-point by having made a thorough investigation of the food habits of the species concerned, prosecuted by disinterested and properly qualified parties.

COAL-TAR CONTEMPLATIONS

By Dr. VICTOR ROBINSON

PROFESSOR OF HISTORY OF MEDICINE, TEMPLE UNIVERSITY SCHOOL OF MEDICINE

CHEMICAL processes were known to the pre-Greek nations before Empedocles speculated on the elements and Democritus defined the atom. There is no question of the lineage of an art once called the holy art, the hidden art, the black art, the Egyptian art. The more we realize the antiquity of chemistry, the stranger it appears that chemical education is an idea of modern times. There was no school of chemistry until a youth of twenty-one opened his laboratory to students at Giessen: the innovator was Liebig and the date 1824. Prior to that time, the general student could enter the chemical laboratory only through the door of an apothecary-shop. Liebig later traveled through England, and as he found no chemical laboratories for public instruction, he informed his friend Wöhler: "England is not the home of science."

England waited until 1845 before establishing, under the tutelage of Hofmann, its first college of chemistry. If we wonder how it happened that the German chemist, August Wilhelm von Hofmann, appropriately born in Giessen and trained by Liebig himself, should be teaching in London instead of Bonn or Berlin, it must be remembered that the Greeks were wise in exalting chance to a divinity. Hofmann, whose discovery of formaldehyde was only an incident in a career of splendor, remained nearly twenty years in London because Queen Victoria happened to love her German cousin. Prince Albert, particularly interested in the application of science to industry, persuaded Hofmann to undertake a perilous experiment: to give up the work that lay before him and build a college of chemistry on foreign soil. Not until Eberth's bacillus removed the prince-consort from the scene, did Hofmann return to his fatherland.

Hofmann's initial research, carried on in the laboratory of Liebig, was on coal-tar: after discovering the nature of aniline, which ever afterwards he spoke of as his first love, he succeeded in finding in coal-tar the hydrocarbon that Faraday originally found in oil gas—the mystic fluid, benzene. Among those who heard Hofmann expound coal-tar chemistry was a rector's son, Charles Blachford Mansfield. Ill health delayed his formal education, and the pupil was only one year younger than the teacher. Mansfield became absorbed in the fractionation of distillates, and devised the apparatus and method by which benzene could be recovered from coal-tar. In Hofmann's laboratory, Mansfield thus laid the foundation of the coal-tar industry, though years passed before benzene became commercially available. Mansfield's pioneer monograph on "Aeral Navigation," his brilliant letters from Paraguay and Brazil and his theory of salts, all presaged an unusual career—his Portuguese translator wrote of him as "a great soul stirred by mighty conceptions and the love of mankind"—but the benzene which Mansfield liberated from its prison proved his Frankenstein. Before his thirty-sixth birthday, preparing samples of benzene for the Paris Exhibition of 1855, he saved a building from destruction by running outside with a blazing still in his hands. Mansfield was fatally burned and died in Middlesex Hospital.

There was mourning in Hofmann's laboratory, but work must go on. One year after Mansfield's tragic end, the laboratory was alive with excitement over another pupil, William Henry

Perkin. Learning from his teacher that a basic nitrogenous substance in coal-tar is also the parent substance of alkaloids, young Perkin spent the Easter vacation of 1856 in his amateur laboratory at home, trying to make artificial quinine. (It was an audacious thought, for a generation was to pass before Albert Ladenburg built up conine—the first synthesis of an alkaloid—while the synthesis of quinine has not yet been achieved). Perkin's experiments produced nothing until he treated Hofmann's beloved aniline with bichromate of potash and sulfuric acid. Then the fortunate youth saw before him a darkish precipitate which yielded him a dye. It was Perkin's Purple, subsequently known as Aniline Purple and Tyrian Purple—a modern chemical link with ancient Phoenicia—and now called by the French name of mauve or mauvein. It was the first of the aniline dyes to be discovered, it was the definite creation of the coal-tar color industry.

Perkin bade farewell to the college of chemistry, took out a patent and with the aid of his family erected a factory at Greenford Green, near Harrow, to color the textiles of the world. It adds considerably to the interest of the situation to recall that this new captain of industry, who revolutionized the dye-vats of civilization, was a boy of eighteen. The life of Perkin was indeed a succession of triumphs. Nature placed fragrant coumarin in the tonka bean, in sweet woodruff and in yellow melilot, but Perkin prepared it chemically, the first artificial perfume. Cloth dyed with madder was wrapped around Egyptian mummies, and in the days of Herodotus the cloaks of Libyan women were colored with madder. In later times, hundreds of thousands of acres, stretching from southern France eastward toward Arabia, were devoted to the cultivation of the madder plant. The factory ruined these fields when alizarin, the red dye of the madder root, was prepared from coal-tar by Perkin. In his mid-thirties, at a time when most men are fighting for a foothold in business, Perkin retired from manufacture to pursue his researches without interruption. He then gave to organic chemistry the method of condensation of aldehydes with fatty acids —Perkin's reaction; and in physical chemistry he demonstrated the relationship between magnetic polarization and chemical constitution—Perkin's law.

Elected a fellow of the Royal Society in his twenties, president of various technical associations, the recipient of complimentary doctorates from universities and of the Davy medal and the Albert medal, Perkin was accustomed to honors, yet the international celebration, in the summer of 1906, must have stirred even that much-honored man. Perkin was now a bearded patriarch, the father of four daughters and three sons, and each of the sons was a distinguished chemist. On this jubilee of his discovery of the first aniline dye, nation and nation testified its esteem of Perkin. His country bestowed knighthood upon him; France gave him the Lavoisier medal; Germany —in the person of Emil Fischer—gave him the Hofmann medal; the United States founded the Perkin medal for American chemists, and he received diplomas sufficient to cover his largest wall. The following year he died, and the public has not yet learned that this man was one of the moving forces of modernity.

Queen Victoria's husband, a victim of typhoid fever at forty-two, lay sleeping in his magnificent mausoleum, but the sagacity of Prince Albert had long been vindicated, for Hofmann's laboratory was the ovum from which developed the coal-tar industry. Chemical industry is not new: its origin is found in the blowpipes of the Egyptians, the dyeing-vats of the Tyrians, the glass-furnaces of the Assyrians, the kilns of the Babylonians, the petroleum-fires that burned on the altars of the Hebrews. The coal-tar industry is not the beginning, it is the con-

summation of centuries of chemistry. Coal-tar, dark, thickish, neither a liquid nor quite a solid, a useless residue clogging the pipes in the making of illuminating gas, has become, in the Perkin era, a central item in the wealth of nations.

Nature has filled the tar-barrel with a lavish hand, and it has brought color and comfort to mankind. It is the philosopher's egg, the elixir of life of the modern alchemist. A remarkable Materia Medica could be compiled, limited entirely to coal-tar products. The rejected nuisance, the despised by-product of the past, is nature's own laboratory, whose magic alembic distills fluids and vapors and scales and crystals for the alleviation of suffering. From coal-tar and allied substances are derived countless synthetics which have replaced the herbs of our forefathers. Among these remedies are the antiseptics, phenol, cresol, resorcin; the local anesthetics, alypin, novocaine, stovaine; the hypnotics, veronal, adalin, luminal; such antipyretics as pyramidon, acetanilid and that household fetich, aspirin. Out of the tar barrel, the exhaustless hope-chest of science, have come such diverse medicinals as saccharin, the permissible sugar of the diabetic; atoxyl for sleeping sickness; and salvarsan and neo-salvarsan for the conquest of syphilis.

Parasiticides and perfumes, fuels and photographic supplies, the asphalt of the pavement and the varnish on the roof, are all born in the deep womb of coal-tar. Cradled in England, the coal-tar industry reached maturity in Germany. Coal-tar industrialism has grown too big for ethical control. Worship of the chemical god was one of the economic factors of the world war. Perhaps it is time for the generation that has grown up in the shadow of the machine age to heed the words of Aristotle. "Industrial work," said Aristotle, "tends to lower the standard of thought." In our era it has lowered the entire standard of human behavior. Every discovery of science is now tested in the counting-house of commerce. It is only poetic justice that in the world war, coal-tar which gave man the healing antiseptics, chloramine-T and dichloramine-T, to soothe his wounds, also gave him trinitrotoluene—the dreaded explosive, T.N.T. —and poison gas. Over the fields where man has shed the blood of man, forever sounds the challenge: "After two thousand years of mass, have we got as far as poison-gas?"

On the eve of the centenary of Perkin's birth, one is reminded of the Enoch Saga. In the Ethiopic Book of Enoth it is written that the angels who visited our world were earth-bound by the beauty of woman; instead of returning to heaven, as all good angels should, they married the daughters of earth, and in gratitude for their favors, revealed to their offspring, who were giants, the worth of the metals within the earth and the healing powers of the herbs that grew upon the earth. That this knowledge should not be lost, the fallen angels inscribed their teachings in a book called *Chema,* from which is derived *Chemia.* It is an ill-made legend, compounded from the sixth chapter of Genesis—there are later accretions by Zosimus of Panapolis, the first of the Greek alchemists—but it remains of interest as one of the fabled origins of chemistry. In the Slavonic Book of Enoch it is written that man was created with free will and shown the way of light and of darkness: he turned from the light and lost himself in the darkness. In every generation man stands at these crossroads, facing the same decision. To-day, armed with the new chemistry, so potent for good and for ill, he must choose again. Will he again pass through the gates of greed to follow the old road of racial hatred and war, or will he emerge in the light on the highway of human brotherhood? To-morrow's children will know the answer.

A FORECAST OF TECHNOLOGICAL EDUCATION

By Dr. KARL T. COMPTON
PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

As a form of intellectual effort, forecasting is more notable for its ability to survive failures than for its successes. It flourished with the soothsayers of Egypt and the oracles of Greece; it lost none of its vogue in the hands of the astrologers of the Middle Ages; it is practised to-day by tipsters, weather prophets, investment counselors and a host of similar services.

Wishful thinking and the fact that "hope springs eternal in the human breast" account in part for the hold that forecasters have on us, as does also the human frailty of trying to shift responsibility by making decisions. More fundamental, however, is the fact that almost every rational action has to be based upon some sort of forecast of its future results. Rational human beings, therefore, must of necessity be forecasters.

The progress of civilization may be measured by the trend from superstition to science in forecasting, but this trend has been immensely more rapid in some fields than others. Astronomers can predict an eclipse with stop-watch accuracy a century in advance; psychologists have made at least some progress in ability to forecast probable success in different occupations by measuring students' aptitudes; medical men are as yet powerless to foretell when or where the next epidemic of infantile paralysis will break out. All grades of forecasting, from hocus-pocus and racket to art and science, coexist as part of man's struggle for a more satisfying life.

Having thus defined the field and exposed the uncertainties of forecasting, I immediately confess that my present excursion into this realm lies somewhere in the scale between racket and science, at about the point usually described as "hunch." My logic may be faulty or unforeseen conditions may arise to change the picture, but, as I see it, technological education in the future will show the following characteristics:

(1) The importance of technological education will continually increase. This appears to be the sure result of three factors: first, the increasing competition which is forced upon individuals and organizations as the opportunity for free expansion into the unoccupied frontiers of the West disappears; second, the necessity of using and husbanding our natural resources more wisely as these become less and less available for easy and wasteful exploitation; third, the increasing applications of science to minister to human needs and desires, which are so important a feature of our so-called rising standard of living.

(2) There will be increasing differentiation between technological and technical training, *i.e.*, between the engineering school and the trade school. The field is rapidly becoming too complex to be included in one and the same curriculum, and the school which attempts to straddle both will succeed in neither.

(3) Large industrial units or associations will increasingly establish their own trade schools to train expert technicians for their own special purposes. Private or public technical schools will similarly supply the general needs of the surrounding industrial communities for skilled mechanics, lithographers, textile workers, electricians, draughtsmen, and the like.

This system will practically replace the older apprentice system which, for better or worse, is rapidly disappearing.

(4) Undergraduate curriculums in technological schools will increasingly avoid specialization except in rather general fields, and will devote increasing attention to physics, chemistry, and the general principles and methods of engineering, with supplementary education in social science and training in the art of exposition. Such broad and basic training is needed to give the vision and adaptability required for positions of responsibility in a world of activities which are increasingly dependent on applications of science in new and varied ways.

(5) As a corollary, the increasing need for many technological specialists will be met by the graduate curriculums, and we may expect a continuation of the recently growing emphasis on graduate study.

(6) We will see increasing differentiation in scope and more logical adaption to environment in our colleges and universities. This will be forced upon them by competition or achieved voluntarily after wise appraisal of opportunities. Most of our present colleges were founded in the era of horse and buggy or limited rail transportation. Most of them were intended to minister to local educational needs. As transportation becomes faster and easier, and the people become more travel minded, why should an ambitious young man try to secure a specialized training for a profession at Podunk College, when a few hours of travel will give him the superior education of a great institution?

Obviously this tendency is more pronounced in the higher grades of the educational system, such as the professional and graduate schools. We will, therefore, see many a smaller or less favorably situated institution drop its ambitious attempts to encompass the whole field of education and concentrate its resources to do the best possible job as an undergraduate or a junior college, perhaps retaining some special field of local significance. At the same time, the higher ranges of education will be concentrated in the most favorably situated institutions. Even among these, the selective process will operate, and we will see a few of them emerge as superprofessional schools, with the graduate aspect strongly emphasized.

(7) Research will become a continually more important activity in the leading technological schools. Two important factors conspire to bring this about, one pedagogical and the other social.

As to the first of these, it will suffice to remark that research, *viz.*, investigation and report of some problem conducted intensively and relatively independently by a student, aided by all the resources of library, laboratory and consultation which he can marshal, supplies a test and training for an important element of his future career, which are not afforded by ordinary classroom or laboratory methods of instruction. Research, as for graduation theses, is a more expensive type of training than lecture, quiz and laboratory exercise; it is far more difficult to handle properly by the faculty, but if so handled it is likely to be fascinating to the student. I believe research to be capable of great development as a feature of education, both graduate and undergraduate, and those schools which are able to handle it adequately will take a predominating place in the educational world.

The social basis for research in educational institutions lies in the combination of urgent public need for research and unique opportunities for performing some kinds of research in educational institutions. Such institutions have extensive and varied laboratory equipment, large staffs in many related fields of science and art, and a great supply of young men available as students or apprentices to work under expert guidance. There

is thus a dovetailing of interests and facilities between education and research, which is mutually most favorable.

Public welfare calls for research from a multitude of angles; new developments in industry, public health, agriculture and all technical fields depend on progress in pure science and development of new materials, processes and methods. While industrial organizations can profitably conduct research on problems related to their specific interests, and governmental agencies can properly undertake research in specific fields of wide public interest, none of these is justified or equipped, as are the educational institutions, to engage in the general advancement of knowledge on which all depend in the last analysis.

For such reasons I look for an increased activity in research in the technological schools and for their support by the public in this activity. Such support will come in a variety of ways: by gifts from public-spirited benefactors; by contracts from industrial associations for investigation and report on fundamental or obscure problems of general interest to the associations; by grants directly by the government in support of important scientific programs. The first of these is one of the finest outgrowths of the American capitalistic system; the last two are logical ways in which the benefits of research, specifically rather unpredictable but of unquestioned value in the aggregate, may be supported by the group for the general good. Recent practices of certain governmental bureaus and provisions in Congressional bills indicate a strong trend toward recognition of research in educational institutions—even outside the land-grant group—as a proper and desirable expenditure of public money.

(8) Finally comes the question: "Will increasing taxation and other methods of forcibly distributing wealth so cripple private philanthropy in this country as to sound the death knell of the privately supported educational institutions, leaving all education in the hands of the state?" Inflation and taxation in an essentially socialistic state could accomplish this. If it should happen, education would be a major loser in the general catastrophe. Fully admitting the splendid work of many state-supported universities and their essential contribution to our national life, it is, nevertheless, the independent institutions which have set the pace and maintained the intellectual integrity and freedom of our entire educational system. Lose them, and the whole structure is freely exposed to the danger of political manipulation and domination.

Private institutions can pay their key men salaries larger than those of the average voter or political office holder, can undertake intellectual projects of no obvious practical value, can report facts or announce theories without thought of the political strife of the moment. Such things are not so easy in a state-controlled school, and would be vastly less easy if the bulwark of tradition and example of the private institutions were destroyed. State institutions suffer under still other handicaps: It is easier to get appropriations for buildings, which show, than for the staff, which really makes the institution; the institutions tend to become pawns in the game of taxation and budgets, with the staffs playing the rôle of very nervous onlookers and the presidents forced to mingle lobbying with educational administration; the pressure to expand activities and serve all groups works against concentration on essentials and maintenance of high standards. Elimination of independent educational institutions would, therefore, not only sacrifice educational leadership, but would enormously increase the difficulties in spite of which the state institutions are now performing their functions so splendidly.

I do not believe that the basic good sense of the American people will permit these things to happen. I believe that our tradition of freedom, initiative and individual rights will continue to develop men and women who will acquire wealth and who will wish to use it for outstanding benefits to the general social group, in which education is an important element. I do believe that the economic trends are making the path of the private institutions more difficult and that some of them will succumb. The trend, I believe, will be for state institutions to assume more of the burden of ordinary education, expanding from the public-school field into the junior-college field, thus substituting education in place of unemployment.

Conclusion

If these forecasts do not entirely miss the mark, they offer both encouragement and guidance in our efforts to make the privately controlled institutions of technology of the future preëminently strong and serviceable institutions. Above all, they indicate that the *criterion for survival of a private institution will be that it offers a quality of education and public service, definitely superior to that obtainable in government-operated institutions.* This is the challenge of the future to those who administer the affairs of private institutions and to those who wish such institutions to endure as vanguard and bulwarks of a free and progressive social order.

PIANO TOUCH

By Professor CARL E. SEASHORE
THE STATE UNIVERSITY OF IOWA

One is tempted to say that touch is the touchiest subject in musical circles, because we are deeply impressed with the enormous possibilities for characterizing musical artistry and expression of musical feeling in terms of this art. The vocabulary descriptive of touch now current is extensive, loose and baffling. Historically, but little effort has been made to aid the student in music by bringing order out of this chaos from a scientific point of view. However, recent scientific approaches to this subject have made progress and give assurance of the possibility of an adequate analysis, description and terminology for many of these phenomena. The best available book on the subject for musicians is the volume by Professor Ortmann, director of the Peabody Conservatory of Music. It is based upon a searching analysis of historical, theoretical and experimental evidences. His principal findings may be summarized as follows:

The pianist has at his direct control only two of the four factors in music; namely, intensity and time. Pitch and timbre are determined primarily by the composer and the instrument.

The pianist can control the intensity only in terms of the velocity of the hammer at the moment at which it leaves the escapement mechanism, and by the action of the pedals.

There are only two significant strokes on the key: the percussion and the non-percussion. The difference between these is that the former contributes more noise to the piano tone and the latter gives the player better control of the desired intensity.

Aside from the addition of the noise, the player can not modify the quality of the tone by the manner of depressing the key or by manipulations after the key has struck its bed except, perhaps, by a momentary partial key release and immediate key depression, damping the tone somewhat but not entirely.

He can control the time factors which

influence quality only by the action of the dampers either through the keys or the pedals.

In general these facts have been known for a long time by instrument makers and leading musicians. But many musicians have failed to recognize their significance or admit the facts. Indeed, experts in various fields of acoustical science also have questioned the findings enough to justify taking the problem into their laboratories for analysis and verification. However, all the investigators have reached the same conclusion on the above points. Let us examine each of the essential factors in turn.

In so far as it depends upon the stroke of the key, intensity (the physical fact) or loudness (the mental fact) is a function of the velocity of the hammer at the moment that it impinges upon the string. After that the tone can be modified only by action of the dampers. The piano action for any key consists of a compound lever system, the purpose of which is to facilitate and control the force of the blow on the string. Let us consider the nature of the blow.

If a ball is placed on the inner end of a cleared piano key and the key is struck in the usual manner, the ball will fly from the key up against the string. Nothing can influence the velocity or the direction of the ball after it has left the key, and the ball can energize the string only at the moment of impact because, due to resilience of the compressed felt and the throw of the string, it bounds off instantly. The function and action of the hammer is analogous to that of the ball. The velocity of the hammer is determined by the velocity of the escapement lever at the moment the hammer is released for its flight, and the force of the blow is determined by the velocity of the hammer at the moment of impact. From this, several considerations follow:

(1) It makes no difference whether the key is struck by an accelerating, retarding, even, or any form of irregular movement; the only significant thing the player controls in the stroke is the velocity of the key at the exact moment that it throws off the hammer.

This easily observed physical fact has profound significance in the theory of playing, hearing, enjoyment and critical judgments about music. The economic aspect is not to be ignored when we consider what money is spent in trying to teach pupils to do something that can not be done. It takes away a great deal of glamor and grace of mannerisms in the mode of depression of the key. It reduces touch to the fundamental factor of intensity.

This should in no way detract from the resourcefulness of the instrument and the opportunity for individual expression or the indirect effects of intensity, which are legion. On the other hand, it clarifies, glorifies and reveals the extraordinary refinement that is necessary in this artistic touch. The elaborate care taken in the development of form, weight, pressure and rate of arm, wrist and finger movements is fully justified in so far as it results in a refined control of the intensity of the tone but not for any independent change in tone quality.

(2) The hammer is released just a trifle before the key reaches its bed. Like the ball, it has only one form of contact with the string; namely, an instantaneous impact followed by immediate rebound. The movement of the key can not influence the hammer after it has been released any more than it can influence the flight of the ball after it has been thrown off. Therefore no amount of waggling, vibrating, rocking or caressing of the key after it has once hit bottom can modify the action upon the string. The only way in which the key can further affect the string is by a new stroke of the hammer. This can easily be verified by manipulating a key near its bed and looking at the action of the hammer.

Probably the only exception to this

statement is the rare or doubtful possibility that a partial release of the escapement mechanism may re-engage the hammer stem so that the hammer may again be thrown against the string and a partial damping may result. However, even if physically possible, this is merely a stunt and is not attempted by artists under normal conditions of playing. Yet this fallacy plays a rôle in musical circles in at least three important respects. First, whenever this stunt is affected, the observable finger action serves as a suggestion which produces the desired result in the form of an illusion of hearing. Such normal illusions have a very great influence upon musical hearing. Second, in ignorance or defiance of the physical limitations, teachers often attempt to train pupils in the supposed art of this type of finesse. And third, theorists who oppose the limitation of touch to intensity control frequently fall back upon this phenomenon to sustain their claims. However, all well-informed musicians recognize that this feature is not important in their artistic playing. Therefore, we may ignore it in the discussion of the real factors in musical touch.

(3) Indirectly the pianist can produce a great variety of tone qualities, but only by his control of the intensity of the tone. Having imparted a given velocity to the hammer, the pianist is entirely at the mercy of the instrument for the determination of qualitative changes taking place in the tone, except for manipulation of the dampers. The piano is so constructed that it can produce a vast series of tone qualities, each one a function of the intensity of the tone. Each instrument has its own relatively fixed characteristic in this respect. In general, the louder the tone, the richer it will be in quality.

If we represent a series of intensities by the letters a, b, c, d, *etc.*, and the corresponding degrees of richness and other characteristics of the quality by the symbols a′, b′, c′, d′, *etc.*, then whenever a tone of intensity a is sounded, a quality a′ is produced; intensity b for the same tone will always yield a quality b′; intensity c or any other intensity will always yield its corresponding tone quality. It is possible therefore to calibrate any particular piano in this way and to set up a scale of intensities which will yield approximately the corresponding scale of tone qualities. However, the situation is complicated by the fact that each instrument has its own resonance characteristics and responds differently to different chords.

This setting up of a scale of equivalents for intensity and tone quality is just what every pianist has to do empirically. Rarely is it a clearly conscious effort or scale; probably it can best be described as a relationship which he has felt himself into more or less subconsciously.

(4) In 1933 Ghosh demonstrated that within a considerable range of the intensities normally functioning in music, the wave form of the vibrating string and therefore the resulting harmonic constitution remains constant. Thus, within a moderate range of changes in intensity, the player can not modify the quality of the tone as it emerges from the string.

The qualitative changes which come with changing intensity are the result of resonance, reverberation or damping effects of the sounding board and the rest of the piano, the thuds and rattlings on the keys, as well as the acoustical characteristics of the room. The wave emitted by the sounding board and its accessories is very much stronger than the wave emitted from the string, and therefore becomes dominant in hearing. The wave form that impinges upon the ear is an amplification and modification of the wave form emitted by the string. This principle applies to all other musical instruments.

At the present time artists regard inharmonic and percussion accessories to piano response as legitimate and essential contributions to tone quality. Is it possible that this attitude may change? We are facing an era of radical change in the nature of music. It is difficult to predict what will happen to concepts of piano playing. Several factors must be taken into account.

First, the piano of to-day, the manner of its use and the tastes and habits of hearing are determined in large part by the heretofore existing mechanical limitations to construction of the instrument. This piano quality involves a variety of thuds, rattlings, raspings and various other forms of noise which are utilized for musical effect and add pronounced characteristics significantly to the tonal elements, especially in the louder intensities. It is, to a considerable extent, in the impurities of tone that we differentiate instruments.

Second, it is now possible to construct a synthetic-tone instrument in which we may include any desired sound quality, and therefore eliminate any of the present characteristics which may be redundant or undesirable.

Third, in such an instrument, it is now possible to introduce a vast variety of tone qualities which we have not been able to produce with our present instruments. We must, therefore, consider the possibility of thinking of the future of music in terms of instruments in which the characteristics are not due to the limitations in mechanical construction but are the deliberate choice, the result of invention and discovery of entirely new tonal complexes for musical satisfaction.

Fourth, it is a matter of history and psychology that likes and dislikes, tolerance and intolerance, artistic cravings and urges, are matters of development contingent upon the tendency to make the best of what we have, the biological tendency toward new habit formations and the inherent artistic merit in innovations.

These situations the piano shares with all other instruments. Conservatism tells us that there will be no sudden change, but insight into the nature of the situation tells us that the change will be radical, and that it must of necessity be in the interest of higher levels of musical achievement with new problems for the composer, the performer and the listener.

Is it probable that the electrical flute, clarinet, trumpet or violin will introduce new satisfaction in the purity of harmonic factors so that we can dispense with the noises which at the present time give us the characteristics of the instrument? We may venture to answer that these new resources in electrical instruments will vastly enrich our world with harmonic tones and will "chasten" or replace many of our present instruments, but there may always be an artistic demand for inharmonic elements, and other noises and percussion features.

(5) Pianists have fairly clear concepts of characteristics of tone quality, such as harsh, brilliant, mellow, full, singing, round, shrill, dry, metallic, steely, brittle, shallow, poor, ringing, clear, velvety, bell-like, jarring and strident. Ortmann performed an experiment in which a number of distinguished artists participated and were able to produce the qualities just named to their general satisfaction. But a recording device attached to the piano revealed that the only two variables that had been under their control were the velocity of the hammer blow and the action of the dampers which affected the duration and loudness of the tone, and that, whenever qualitative differences were present, they were differences in intensity and time relationships.

(6) The countless varieties of temporal movement are also reduced to the operation of time, with some modification by

intensity. Ortmann performed experiments in which accomplished pianists gave artistic expression to such marks as *accelerando, ritardando, affettuoso, espressive, scherzando, etc.* The recording device on the piano revealed the fact that all these characteristics of musical movement were completely controlled by the two factors, the time relationships and the intensity of the tone.

(7) The pianist can modify quality through controlling the time factor in three ways: the tempo and the temporal aspects of rhythmic features are determined largely by the duration of vibration as determined by the moment of application of the dampers through the release of the key; the vibration may be continued by overholding the notes with the sostenuto pedal.

It is well known that the piano tone fades out rapidly soon after the hammer stroke; but the listening ear tends to ignore this and, instead of hearing tones as having sudden changes in intensity and timbre, tends to hear the initial characteristic of the tone until the next key is struck, in spite of the fact that the physical change in the tone is very radical. For this reason, it seems to make relatively little difference whether a key is held down for the entire time assigned to it in the score. As a matter of fact, the player is often irregular and relatively indifferent in regard to the time for release of the key, especially in rapid movements. He depends on this tendency in hearing to carry over. In musical hearing the effect of overholding the note by pedal is perhaps more evident in its modification of resulting tone quality than in the awareness of the continuation of the note or chord as such.

(8) The most profound change the artist can give to tone quality comes through pedal action. By means of the sostenuto pedal tones may be carried through a series of chords after the respective keys have been released, thus producing great enrichment in the harmony through the gradual overlapping and fading of antecedent tones. Refinement in the use of this medium is an outstanding mark of artistry.

In the use of the una chorda pedal the artist has a choice of striking one, two or three strings. Two effects result. The softer felt tends to dampen partial vibrations of the string and the remaining string or strings vibrate in sympathetic resonance. A combination of such tones obeys precisely the same laws as tones produced without pedal although the basic tone-complex is altered. The action of the soft pedal involves, of course, purely the factor of intensity.

(9) The great tonal resources of the piano as an instrument lie in the richness of tone produced by the possibility of playing one or many keys, with or without pedals, and thus utilizing both harmonic and melodic progressions. But these are as a rule set in the score by the composer, and the possibility of legitimately introducing variants and ornaments not so indicated is limited.

(10) It is, of course, recognized that the pianist has many devices for changing the quality of tone by freedom in the use of intensity or in time. For example, tone coloring is a very conspicuous feature in artistic playing, but it ordinarily means that the pianist strikes the notes in the chord with different force and thus can produce varying resonance effects from the same chord. Likewise, there are considerable resources in the variety of uses of the pedals, both as to time and intensity. The pianist has various devices by which he can get sympathetic vibrations and modulate overtones. There are also many ways of enhancing subjective tones which may play an important rôle, clearly modifying the perceived tone quality, and we must not overlook the vast array of illusions which have qualitative significance. Last but not least, there is the power of suggestion.

(11) The artist may legitimately think

and perform with tone quality as his objective, and consciously control his touch in terms of tone quality. Likewise the listener may regard tone quality as the primary factor and think of intensity as a secondary and even unrelated factor. But the fact remains that, in general, the only way in which the pianist can produce qualitative changes is through dynamic and temporal changes, and then only within the limits set by the characteristics of the instrument.

(12) It follows from these considerations that a fairly adequate record of musical performance can be made by recording the velocity of the hammer blow and the action of the dampers. With a given composition and a given instrument of which the characteristics are known, we can describe the essentials of artistic performance on the piano in terms of the artist's command and use of these two factors.

The Iowa piano camera is built on this principle. It registers the performance in minute and serviceable detail in a permanent photogram. This can be transcribed into a scientific performance score, in terms of which objective analysis of the tonally significant features of the rendition may be made.

The purpose of this analysis has been to pave the way for a synthesis. In acoustics we have analyzers which may dissect any rich tone into its component partials; conversely, we have synthesizers which can take all known partials of any rich tone and reconstruct the original single sound wave. On this analogy it is here suggested that the principle which justifies our reducing a rendition to its two operating media justifies our assuming that, by reversing the process, we may derive all the salient elements in the performance from an adequate record of these two media. Such matters as phrasing, personal interpretation, the principles of art involved, errors, idiosyncrasies and exhibitions of skill are embodied in such a piano camera record.

FOR SCIENCE

By Dr. A. S. PEARSE

PROFESSOR OF ZOOLOGY, DUKE UNIVERSITY

We live, then, in an age of grave social disorder and threatening chaos; and it is in the main due to science.—*McDougall*, 1935.

Scientific civilization has destroyed the world of the soul. . . . Civilization has created new stimuli against which we have no defense.—*Carrel*, 1935.

THE rewards of success are power, position and hard work; not affluence and ease, as the unsuccessful believe. The penalties of success are jealousy and responsibility. The tycoons of the earth are always the subjects of green-eyed envy. They must care for the so-called unfortunate and tell them what to do. They are blamed for hard times, plagues, famines, hurricanes and other "acts of God."

During the past century science has been successful. It has made the world more or less cosmopolitan, safe, comfortable, healthful, tolerant, honest, sensible and understanding. Naturally it is blamed by non-scientists for the troubles of society. Critics of science gleefully point out that scientific theories grow into dogmas which impede the progress of civilization as much as those of theologians, politicians or economists; though scientists have labored for generations to explain natural phenomena, the world is still full of mysteries; though knowledge has increased enormously, man is still wicked. Perhaps the worst sin that science has perpetrated is the giving to civilized man comfort, convenience and

leisure, so that he does not have to think daily about how he is going to live through. Science has come, the good old days are gone forever; man has not only become soft and degenerate, but remains sinful.

As Shaw says in his introduction to Saint Joan, "Men fear what they do not understand." The writer begs leave, as a scientist, to say a few words for science and will attempt to give some idea of what science stands for and what it is. "The laboratories have conquered, but their triumphs are sealed within their walls."[1] The first author quoted at the head of this essay in a recent book[2] states that science is mechanism, and that mechanism is anti-religious. He then skilfully and astutely destroys his straw man. Of course almost any fellow on the street knows that scientists have very diverse views on religion. It is a mistake to attempt to raise the old issue between science and religion; alive in the days of Spencer and Huxley but now dead. Most scientists respect religion and appreciate what it has done for man. Today thoughtful theologians do not blame science for the troubles of the world. An everyday man is quite satisfied to enjoy the benefits of religion and science without worrying much about either. A few agitators continually shake bugaboos before the public and thus magnify their own importance. Some of these are wild enthusiasts; some are just gossips.

Dr. Carrel[3] says that science has "destroyed the world of soul." This is true in so far as "the scientific method" has made people more sensible and critical of archaic, primitive and naive notions of souls, but it has by no means done away with belief in souls and God, even among scientists. Perhaps the clearest discussion of the relations between science and metaphysics has been presented by Bergson.[4] He points out clearly that science can never do anything but weigh and measure. All a scientist can ever hope to do is answer such questions as how long?, how fast?, how wide? and how much? In addition to knowledge gained by weighing and measuring man may know other things, and these Bergson groups under intuitive knowledge. The crux of the matter is, are there things that can not be weighed and measured? Bergson, most theologues and many scientists believe that there are.

Theoretically science can do no harm. Its sole purpose is to learn the truth about natural phenomena, and truth should hurt no one. Unfortunately scientists are human. They are sometimes just as bigoted and partisan as other men. Some scientists are capable of concealing truth or of telling half truths to help their cause. Some have used discoveries to injure their fellows. But there is nothing inherent in science, its methods or its teachings that should make men wicked. If a man has scientific spirit, he is brave in the defense of truth, but humble before the mysteries of nature. A scientist will always respect evidence more than authority. If he is also a gentleman, he will be open-minded, tolerant, critical but kindly, courageous but cautious. He will perhaps be characteristically methodical, painstaking, accurate, persevering and modest. Such a man, if he is in the least worthy, will not waste his time asserting that religion or other matters about which he knows little or nothing are evil or worthless. He will attend to his own business.

Science has not changed the nature of men or of their societies. It has given opportunities, and men have chosen to use these to make themselves better or worse. The false assumption on the part

[1] O. Riddle, *Science*, 83: 69–74, 1936.

[2] "Religion and the Science of Life." Durham, N. C. xv + 263 pp.

[3] "Man, the Unknown." N. Y. xvii + 346 pp.

[4] H. Bergson, "An Introduction to Metaphysics." N. Y. iv + 92 pp. 1912.

of critics is that a scientific discovery should mean progress for society. The radio gives man unusual ability to communicate over great distances. It may be used to give notice of storms and to keep ships on their courses through dense fogs, and thus benefit man; but it is also used to send out misinformation (Zion City informs listeners that the earth is flat) or to spread selfish propaganda.

It is not the business of science to make men good. Incidentally scientific methods of thought may tend to make men more sensible and honest with themselves. But through all time to come men must as individuals or groups struggle toward idealism along paths that their time and social positions make possible. "Human beings are much alike over time and space. For many thousands of years man has been substantially the same kind of physical being as he is to-day. . . . The simplest form of all societal institutions is custom. . . . Nowhere is real knowledge and science so little in intelligent demand as in the societal realm, for the latter is self-sown to whims and dreams of all varieties. . . . There is one common misconception about evolution, that it means progress. It means adjustment only."[5]

A man must adjust himself to society in the particular time and place in which he happens to be situated. Some independent spirits resent the daily formal observances that civilization exacts and revolt, in words or deeds. The tiresome routine of formal life tends to fill any man with ennui. But man, or society as a whole, does not advance by throwing away established customs and starting anew. Accepted ways of doing things may appear to be silly in the light of pure reason; established notions of right and wrong may not be sensible, but must be observed if one is to be a normal, accepted member of society. A professor must wear a necktie when he appears before his class, but he does not dare to appear with a creation about his neck that on a student would merely be looked upon as "snappy."

Science is a product of modern civilization. It has been created by sweating, thoughtful men—men like ourselves. Scientists such as Pasteur worked to make nature better serve man; those like Darwin have labored because they felt the urge to drive back the frontiers of ignorance. For such men science was noble and ennobling. Along with the uplifters there are always scientific quacks, charlatans, politicians and lately racketeers. Men are just human beings, and will be as long as civilization lasts. Science is truth, but its applications are what men make them.

[5] A. G. Keller, "Societal Evolution. The Evolution of Man." New Haven. 126–151 pp. 1922.

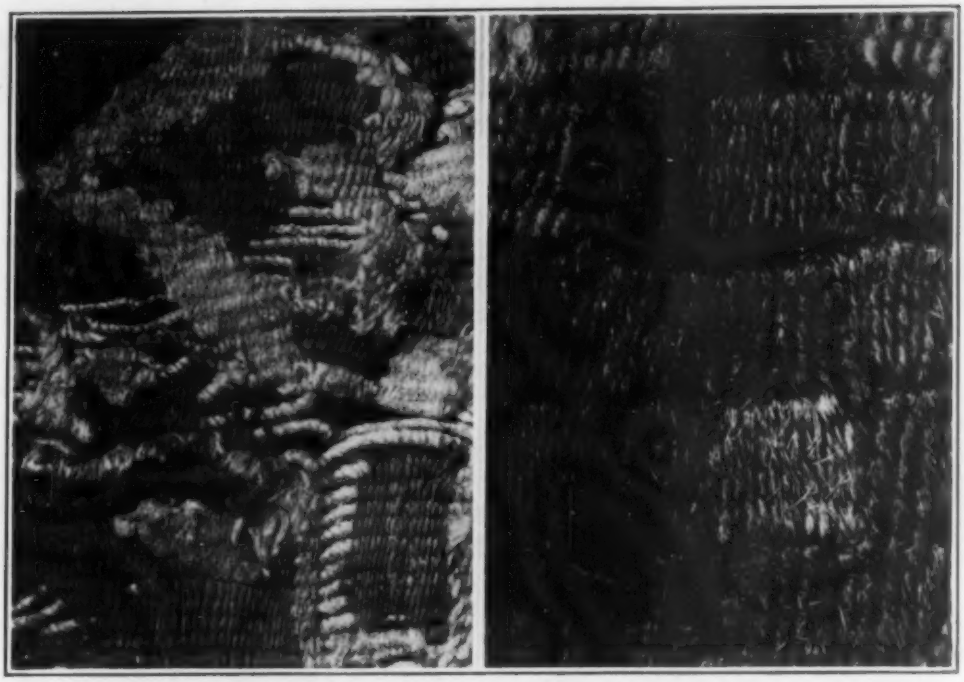
NEW LAMPS FOR OLD IN TEXTILE TECHNOLOGY

By E. R. SCHWARZ

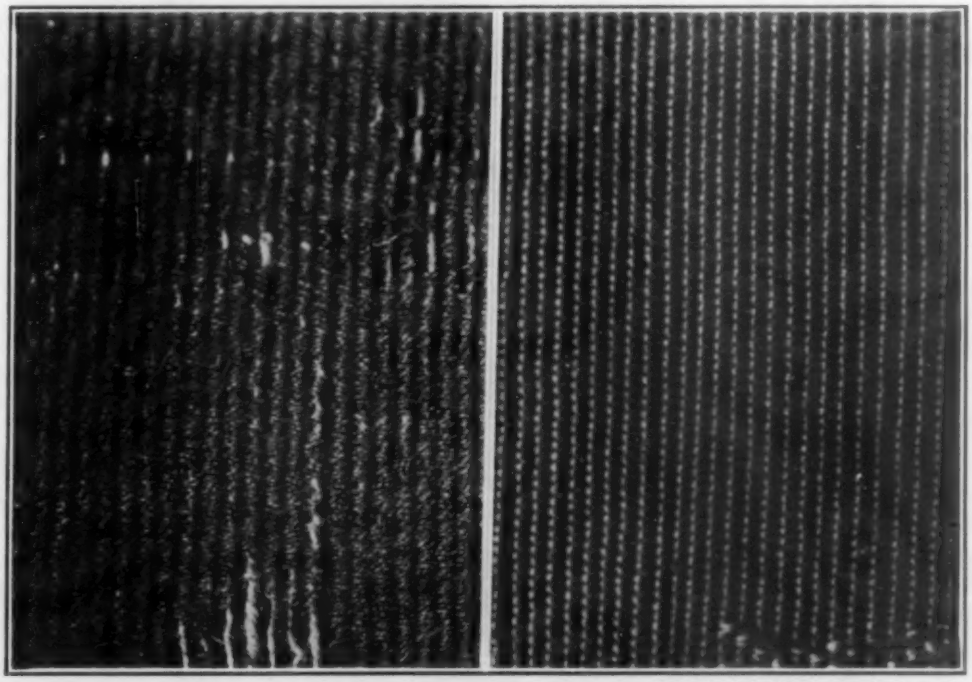
ASSOCIATE PROFESSOR OF TEXTILE ENGINEERING, IN CHARGE OF TEXTILE RESEARCH, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BOTH physics and chemistry are in the last analysis simply concerned with forms of energy and the manifestations in which these forms are combined and displayed. Probably no branch of technology, therefore, can be anything but a combination of these two fundamental sciences. Nor is textile technology any exception. Even without recognition of the fact in the earlier days of the textile industry, nevertheless physics, chemistry, biology and mathematics joined hands to increase and clarify man's knowledge of the fibers which for uncounted centuries had been and still are the raw materials for yarn and fabric. His knowledge, however, became more and more definite and increasingly fruitful, so that while he was not able to do more than but a little toward controlling the uniformity and desirability of the natural fibers which he used, he was eventually able to produce usable synthetic filaments. Yet none of them can be considered substitutes for the natural fibers in the sense of duplication of properties, as we shall see. Animals must still be depended upon to produce wool. Plants are still unique producers of cotton, flax, hemp and jute. Insects are still the silk producers. The future will be satisfactorily prolific for the textile technologist only as the biologist becomes more intimately and exactly acquainted with the nature and processes of life and with the natural synthesis of fibers. Progress will be satisfactory only when the chemist understands clearly the nature of the forces which bind the atoms into molecules and the molecules into chains. Textiles will be the richer—as will science itself—when the physicist can understand the nature of the forces which stabilize the atom. Expression of the laws which will be found to govern these manifestations of energy must be formulated and made workable by the mathematician.

To say that the future of the textile industry rests in the hands of the atom splitter is not to speak utter fantasy. There was a time when the ultimate was expressed by the man who spoke of "splitting hairs." Nowadays the textile microscopist literally splits hairs—and finer structures—as a matter of course. And as perfection of technique allows him to continue along the path of decreasing magnitudes he feels the urge, as one man put it, to unscrew the inscrutable. He is continually recognizing the fact that everything according to the modern physics and chemistry is in the last analysis a more or less complex association of forms of energy. It seems logical, therefore, to employ certain forms of energy which are fairly well understood and controllable for the attack upon the details of fiber structure. The word "attack" is purposely used as being descriptive of the work. The textile technologist literally bombards the atomic structure of the fiber with a hail of machine gun bullets in the form of x-rays. He lays down a barrage of heavier missiles from his mobile artillery consisting of ultra-violet lamps. With his siege guns composed of polarizing microscopes he batters down the last defenses offered by the fibrils, which are



EXAMPLES OF TAPESTRY TYPE OF WEAVE
ANCIENT PERUVIAN FABRICS FROM M. D. C. CRAWFORD COLLECTION.



—*Crawford Collection and M. I. T.*
LEFT, OLD PERUVIAN CORD WEAVE; *RIGHT*, MODERN CORD WEAVE

the smallest visible units in the fiber. The chemist sets to work sapping and mining to plant a high explosive in the form of swelling and disintegrating solutions so that the fiber will be actually blown up. And, strange though it may seem, the microscopist is even engaged in raining incendiary bombs on fibers by means of a hot stage used with the microscope in order that he may study the charred ruins to determine the nature of the inorganic skeleton remaining.

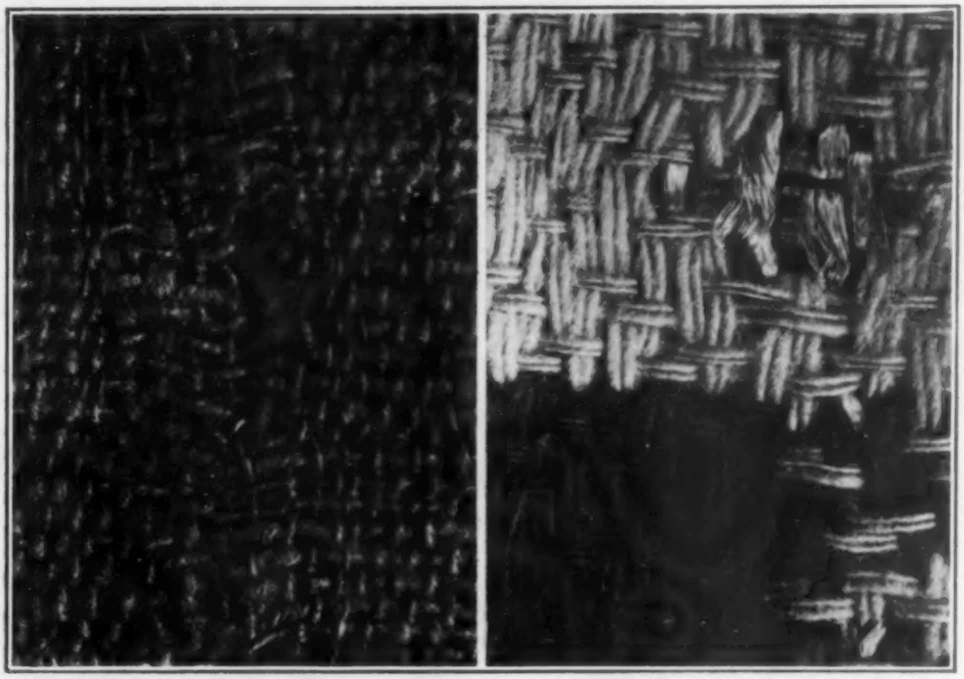
Just as steel is thoroughly tested for its physical and chemical properties before the construction of a machine, bridge or building, so the textile technologist determines the strength, stretch, rigidity and many other properties of yarn and fiber later to be fashioned into fabric. The study is fascinating, for here is a material—simple cloth, if you will—which is composed of filaments each as strong for its cross section as steel, yet producing a structure which is amazingly flexible. For uncounted generations man has adorned himself and his surroundings with more and more gorgeous, more and more cleverly contrived tissues. Not only may the degree of civilization of nations past and present be measured by the kind of buildings which they erected but by the nature and excellence of their fabrics. As the spinning and weaving of textiles was probably the oldest art known to man, far antedating the working of metals, the study of ancient fabrics is an interesting one for the archeologist. Where and how did the fashioning of leno weaves now widely used for draperies and many other purposes originate? How were the lenos of old Peru woven? Was there a connection between the art of tapestry weaving in the old world and in the new? Who originated pattern constructions produced by means of what the modern weaver calls a double fabric? All these questions and many more outline not only a fascinating field for speculation on the part of the archeologist, ethnologist and historian but present a real challenge to the research worker.

Truly there is nothing new under the sun. The insulation of houses with felts of all sorts is supposed to be a recent development, but for centuries the Mongols have lived in felt-insulated yurts. It is not too long a stretch of the imagination to bridge the gap between the felt-roofed cart of Tibet and the felt-insulated top of the latest model sedan. The floor of the newest movie theater is covered with chenille fur carpet made in the same way as the Peruvian pile constructions of thousands of years ago. The ancient and sacred cotton cord of the Hindu holy man who lived long-forgotten years before the Christian era and the coronation robes of this year's proud monarch, after all, have much in common. The men who go down to the sea in ships with their nets and lines can vision a textile thread stretching back through the years to join them to their brother fishermen of the prehistoric Swiss lakes.

Only after the passage of thousands of years has man acquired the temerity to attempt to duplicate what nature has lavishly bestowed for uncounted generations through the instrumentality of the sheep, the plant and the worm. Even the best modern chemist shares humbly with the physiologist the knowledge of his inability to solve the riddle of why the sheep grows wool and not feathers. For feathers and wool are strikingly alike in the kind and arrangement of the atoms which compose them. Dr. Bush[1] has said:

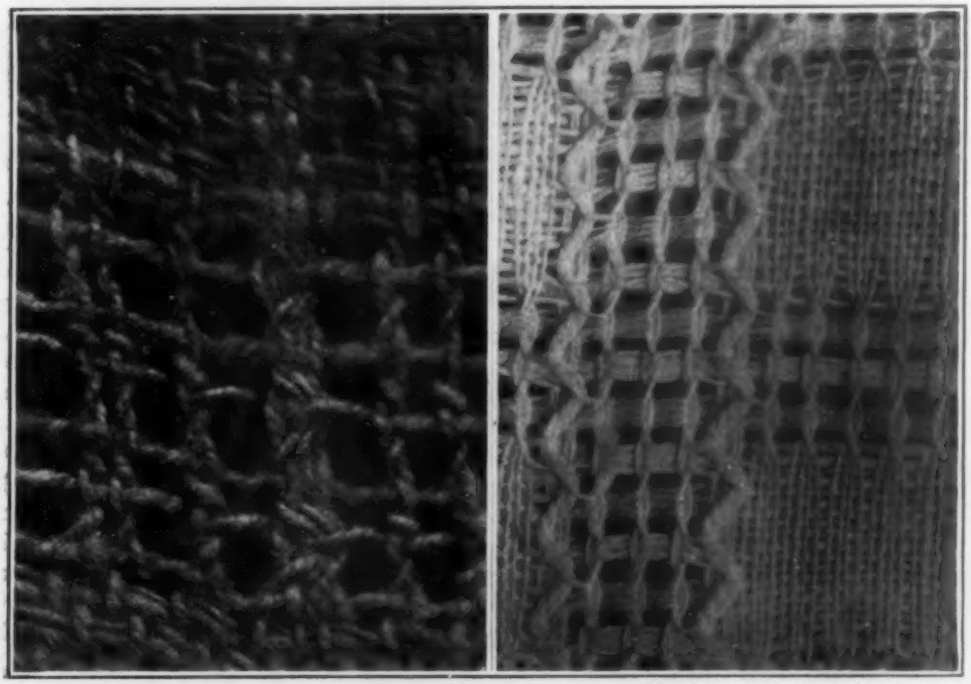
> I have always envied the duck. He can dive under water and come up dry. Yet his coat is pervious to air as it should be for his good health, and it fits beautifully. . . . It is cer-

[1] Introduction to "Textile Research—A Survey of Progress," compiled by the U. S. Institute for Textile Research, Inc., M. I. T. Press, 1932.



—*Crawford Collection and M. I. T.*

LEFT, ANCIENT PERUVIAN DOUBLE FABRIC; *RIGHT*, MODERN DOUBLE FABRIC



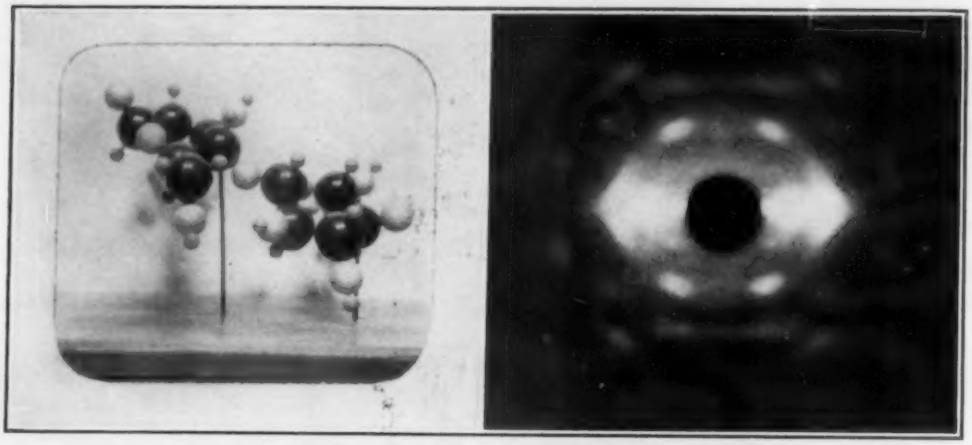
—*Crawford Collection and M. I. T.*

LEFT, ANCIENT PERUVIAN LENO WEAVE; *RIGHT*, MODERN LENO WEAVE

tainly true that Solomon in all his glory was not arrayed like one of our modern women—not a queen but a woman of the people. We have progressed. Yet the lily can still exhibit more pleasing finish and coloring, to my way of thinking; and the grass of the fields presents me with more alluring gradations of greens and browns than I find in neckties. Moreover, the grass takes on more and more attractive hues after long exposure to the sun and rain, and neckties do not. This is not intended to be a criticism of the textile research worker, who, after all, has been studying his subject for only a short time, and who has produced some marvelous fibers and fabrics. Rather we should note that there is no field of human endeavor in which so much ingenuity and resourcefulness has been shown as in textiles, or which has brought more benefit to mankind.

Rayon is an example of this resourcefulness, and it is with us to stay. Great though the story of its progress has been, its future is even greater. No one can tell what discovery of modern science will be interpreted to make rayon the most unique fiber that man has at his disposal. Nor are the natural fibers to be neglected when it comes to scientific research. The quality of most of the commonly used fibers is steadily being improved. Measurement is taking the place of guesswork. Little recognized or appreciated fiber properties are now being used to make better fabrics possible.

For many years it has been known that all textile fibers polarize the light which passes through them. This fact was of purely academic interest until the technique of x-ray diffraction photography and the discovery of what the organic chemist calls the "long chain molecule" came into prominence. Then it was realized that the architecture of the fiber (the manner in which its atomic building blocks are put together) was responsible for the double refractive properties of the fibers. And just as perfection of workmanship makes for strength and permanence in a machine or a building, so perfection of orientation of long-chain molecules makes for strength and uniformity of fiber or filament. The fiber technologist with his polarizing microscope joins the chemist with his polymerizations or degradations and the physicist with his x-ray tubes and high voltage atom splitters to aid the textile manufacturer to better utilize the



THE MOLECULAR STRUCTURE OF FIBERS

Left, MODEL OF ONE UNIT OF CELLULOSE MOLECULE; *Right*, X-RAY DIFFRACTION PATTERN OF BAST FIBER DEMONSTRATING MOLECULAR ORIENTATION.

products of nature's fiber producers, and those which he himself squeezes through a spinnaret.

The machines which attempt to duplicate the combining of fibers into yarn by the skilful fingers of the hand spinner whose art has passed down to him through generations from his cave-man ancestors have been with us for years. Here, too, modern science is making a critical survey of the correctness of the long-used principle of drafting. The cotton lap entering the carding machine as a sheet of matted fiber some 42 inches wide by less than one-half inch thick is drawn out in length more than 30,000,000 times to form a yarn. The problem of insuring that each successive cross section of such a yarn will contain the same number of fibers as every other is almost insoluble by such means. Science must lead the way to better yarn structure.

The familiar loom for weaving fabric uses the fundamental motions of carrying successive filling yarns through sheds formed by the separation of the warp ends, even as the earliest of American weavers, thousands of years ago, carried out the process on his bar loom. The modern loom is a marvelous combination of automatic mechanisms. All these have been added to those first built into a power loom by Cartwright (1743–1823) before he had ever seen even a hand loom. Again science must simplify and improve the fabrication of yarn into fabric.

The ancients used their madder, indigo and Tyrian purple to produce colored fabrics which would not fade. A major problem still facing the textile industry is to produce synthetic dyes which will be fast to use, washing and light. Why certain atoms (carbon, nitrogen, hydrogen and oxygen) which, in one combination, produce the indigo used to dye the silk filament, itself produced by another arrangement of the same atoms, is still to be discovered. This problem should interest all of us, for after all we are all dressed fundamentally in an impalpable powder combined with the essential element of laughing gas, a whiff of the lightest gas we know, plus a fraction of the breath of life. Such are textiles. Such are some of the problems—new and old—of the textile technologist.

VERNON LYMAN KELLOGG

THE PROGRESS OF SCIENCE

VERNON LYMAN KELLOGG

Vernon Lyman Kellogg—scientist, author, teacher, citizen of the world, student of life, promoter of scientific organizations. These are a few of the designations which may be applied to the man who has recently left us (Hartford, Connecticut, August 8, 1937) after a long and useful life which began in the home town of his famous friend, Will White (Emporia, Kansas, December 1, 1867). Between these dates the small-town Kansas boy saw much of the world, served with great leaders in many fields of human activity, contributed usefully to the advancement of biological knowledge, but, above all, stood out as an interpreter of life and its evolutionary development. He received an early impulse toward biological study through association with his teacher and friend, Francis H. Snow, who occupied the "settee" of science and mathematics in the early days of the University of Kansas. When Snow became chancellor of the university, Kellogg served as his assistant and private secretary until he went to California in 1894. At Leland Stanford he became likewise intimately associated with its president, an even more famous biologist, David Starr Jordan, and with him for almost two decades collaborated in the production of numerous texts upon elementary biology and upon the philosophy of biology. During the World War he was on leave and closely associated with another noted friend, Herbert Hoover, in the alleviation of suffering in Belgium and Poland. Upon his return to this country he joined in the movement to establish the National Research Council as the executive body of the National Academy of Sciences for bringing scientific aid to the government in its war activities. Under the peace-time continuation of the National Research Council he was made its permanent secretary, in which office he continued until his tragic illness obliged him to relinquish it in 1932. In this association he was led into many related phases of scientific and philanthropic organization. There he held administrative positions in Science Service, the Council of the American Association for the Advancement of Science, the Rockefeller Foundation, the Brookings Institution and many others. In most of his activities he was associated with powerful leaders whom he served as a faithful and efficient friend.

In his work as an interpreter, however, he went alone, and it is here that he was most at home. Even as a student he felt the urge to share his thoughts and impressions of nature with others. In the local paper he ran a column entitled "Bird Notes," in which the captivating style which characterized his writings early made itself manifest. The broad implications of biology always appealed to him and he wrote extensively upon evolution and Darwinism. In his own studies, concerned mainly with insects, he came to see the value of the practical applications of biology to human welfare and not only wrote upon this subject at some length, but proceeded to an evaluation of Luther Burbank's work. It was not surprising with this background that he turned easily to the practical use of science in the amelioration of human suffering during the war. Equally naturally he extended his thought to the problems of human behavior, so many phases of which appeared in exaggerated form under the stress of conflict, and not only was he a good interpreter of the way people think and act, but he was both able and interesting in his presentation

of observations and conclusions. Kellogg's activities, though varied, sprang largely from his early manifested interest in teaching. At first this followed the conventional personal instruction of student by teacher, but very soon it extended itself into the writing of textbooks for similar types of instruction, passing then into the production of works dealing with theoretical biological questions. Always, however, with the mind of the interpreter, he sought to bring to the general reader some knowledge of the way in which the problems of life and living appear to men who give them serious thought against a comparative biological background. In many other ways he showed his interest in educational matters, utilizing often toward this end the connections established in the National Research Council. Conspicuous in this direction was his chairmanship of the Division of Educational Relations, wherein he had many opportunities for the study and promotion of educational projects. As the years passed there was less and less of writing and teaching and more and more of administration, until it became all-absorbing and excessive—and then the final incapacitating illness brought a lingering end to all physical efforts, although a sustained interest in old pursuits and friends continued to the last. Many responsibilities came to Kellogg and all these he met with ease and ability. Honors came also in corresponding measure, and they were carried modestly and without ostentation.

C. E. McC.

THE ROCHESTER MEETING OF THE AMERICAN CHEMICAL SOCIETY

WITH 3,483 chemists registered, the ninety-fourth meeting of the American Chemical Society in Rochester, N. Y., from September 6 to 10, was the second largest in the history of the society, approaching the record figure of the Chemical Industry Tercentenary meeting in New York in the spring of 1935.

At seventeen divisions and the microchemical section, 472 scientific papers were read. The general session on Wednesday, September 8, which was Central Day, was addressed by Dr. Nevil Vincent Sidgwick, of Lincoln College, Oxford, one of the leaders of the modern school of organic chemistry in Great Britain. Dr. Sidgwick spoke on "The Uniqueness of Carbon." Dr. C. E. K. Mees, director of research of the Eastman Kodak Company, illustrated "Recent Developments in Color Photography."

Dr. Edward R. Weidlein, director of the Mellon Institute of Industrial Research, gave the annual presidential address on Tuesday evening at the Eastman Theater, depicting "A World of Change." America, Dr. Weidlein declared, has achieved the chemical leadership of the world.

"It grows more and more apparent that to help one's country to be chemically independent is the profoundest kind of patriotism," Dr. Weidlein concluded. "The objective of scientific research to-day, moreover, is broader than the solution of technological and chemical problems. It takes into its view the responsibility for enlivening the imagination of the masses who will be the chief beneficiaries of these new ways of living. A true scientist . . . expects to live in a changing world."

Rochester's three largest hotels, the Seneca, Sagamore and Powers, were overrun during the meeting. While the Seneca was the headquarters hotel, divisional meetings were also held at the Eastman School of Music, the Sagamore, the Rochester Club, the Powers, the Rochester Gas and Electric Corporation Building and the Columbus Building.

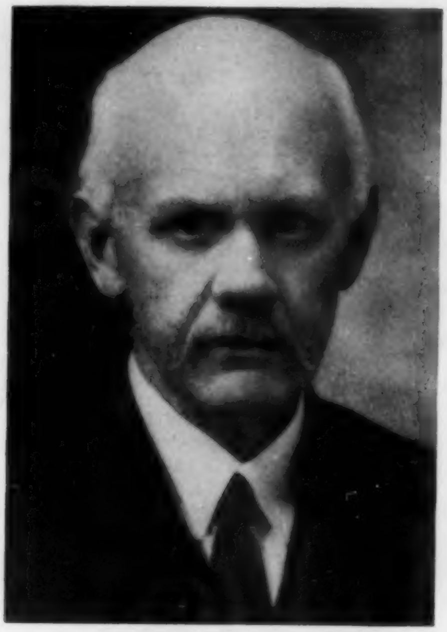
The society's council, convening on Wednesday morning, gave a rising vote of thanks to the members of the Rochester

DEAN FRANK CLIFFORD WHITMORE
PENNSYLVANIA STATE COLLEGE, PRESIDENT OF THE AMERICAN CHEMICAL SOCIETY.

section "for such a good meeting." Secretary Charles L. Parsons reported:

1937 has been a banner year for the American Chemical Society. To date, 2,773 new members have joined the society, making a total membership of 20,538. Subscriptions to the society's journals have also notably increased. When it is taken into consideration that the budgeted expenditure for the society in 1937 is in excess of $622,000, a rough idea is gained of the extent of the society's business and the return it makes to its membership. This is especially emphasized by the fact that of this amount only $186,700 comes from membership dues. Funds necessary for the Third Decennial Index were raised, chemical industry contributing over $100,000 of this amount. Three new local sections have been chartered, one at Wilson Dam, one in the Texas Panhandle and one at Dallas and Fort Worth. Most important of all, federal incorporation to take place January 1, 1938, has been granted by Congress and the act has been signed by the President. This is an accomplishment of the utmost value to the success of the American Chemical Society and its opportunities for usefulness.

The council announced the award of the first Francis P. Garvan gold medal to Dr. Emma P. Carr, of Mt. Holyoke College, "for her researches in physical chemistry, especially on the structure of organic molecules by means of absorption studies in the far ultra-violet portion of the spectrum." Dr. Carr, who



DR. NEVIL VINCENT SIDGWICK
LINCOLN COLLEGE, OXFORD UNIVERSITY, ENGLAND, WHO ADDRESSED A GENERAL SESSION OF THE AMERICAN CHEMICAL SOCIETY.

DR. C. E. K. MEES
DIRECTOR OF RESEARCH AND DEVELOPMENT, EASTMAN KODAK COMPANY, ROCHESTER, N. Y., WHO SPOKE BEFORE A GENERAL MEETING.

DR. EMMA PERRY CARR
MOUNT HOLYOKE COLLEGE.

DR. E. BRIGHT WILSON, JR.
HARVARD UNIVERSITY.

is on sabbatical leave, will receive the medal at the ninety-fifth meeting in Dallas, Texas.

The establishment of a prize of $1,000 and a gold medal for outstanding achievement in milk chemistry by the Borden Company was also announced. The award will be made annually for three years beginning in 1939 under the direction of the society.

The Langmuir Prize of $1,000 was presented on Wednesday afternoon to Dr. E. Bright Wilson, assistant professor of chemistry in Harvard University, twenty-eight years of age, for outstanding experimental work in physical chemistry.

Seventy-one foreign chemists attended the meeting, which "wrecked" the housing facilities of Rochester. Every hotel room in the city was taken, as well as the University of Rochester dormitories and many rooms in private homes. Of the foreign chemists, forty-nine were from Canada, three from Germany, eight from England, two from New Zealand, three from Holland, two from Belgium and one each from Brazil, Puerto Rico, British West Indies and Dutch West Indies.

The plant trips arranged for Rochester were an exceptionally successful feature of the meeting. All Rochester industries were extremely hospitable, opening doors to visiting chemists without exception. There was splendid entertainment and about forty-five special luncheons, dinners and group meetings.

The Symposium on "Are Patents on Medicinal Discoveries and on Foods in the Public Interest?" attracted the largest attendance (something over 500) and the speakers—Dr. Morris Fishbein, of the American Medical Association, Dean H. L. Russell, of the Wisconsin Alumni Research Foundation, and George B. Schley, Indianapolis attorney—were followed by lively and extensive discussion from the floor.

The two-day Symposium on Gaseous Combustion, convening through Thursday and Friday, was the longest one of the meeting and was also very well attended, with time allowance for discussion found too short. Growing interest in the programs of the Microchemistry Section caused its room to be overflowing at all times.

In the History of Chemistry Division, a dramatization of Jane Marcet's "Conversations of Chemistry" was a departure from the standard example of scientific paper. Four evening radio broadcasts brought chemical science down to chatty, informal language, under the direction of D. H. Killeffer, of New York. Nearly a dozen show windows in Rochester department stores and in the Gas and Electric Building were devoted to special chemical exhibits.

CORRESPONDENT

THE SEPARATION OF NITROGEN AND POTASSIUM ISOTOPES

SEPARATION of the heavy isotope of nitrogen for the first time in quantities sufficient to provide a new "tagged" atom for far-reaching investigations of physiological processes and other scientific enigma was announced to the American Chemical Society, meeting at Rochester, by Professor Harold C. Urey, of Columbia University, winner of the 1934 Nobel prize in chemistry for his discovery of "heavy water."

Dr. Urey and his co-workers, Dr. John R. Huffman, H. G. Thode and Marvin Fox, have developed after two years' effort a distinctly chemical method by which two tenths of a gram of "heavy" nitrogen can be produced every twenty-four hours, a speed one hundred times greater than previously attained by scientists who had separated the isotopes, or chemical "twins," by physical means based on diffusion of gases.

With a concentration of heavy nitrogen provided by Dr. Urey, Dr. Rudolf Schoenheimer, assistant professor of biological chemistry in the Columbia Uni-

DR. HAROLD CLAYTON UREY, NOBEL PRIZE WINNER (LEFT) AND DR. JOHN R. HUFFMAN

WATCH THE 35-FOOT COLUMN IN THE CHEMISTRY LABORATORIES OF COLUMBIA UNIVERSITY BY WHICH THE HEAVY ISOTOPE OF NITROGEN, OCCURRING IN THE RATIO OF 1 TO EVERY 262 ORDINARY NITROGEN ATOMS, WAS SEPARATED IN SIZABLE QUANTITIES FOR THE FIRST TIME. DR. UREY AND HIS CO-WORKERS REPORTED TO THE AMERICAN CHEMICAL SOCIETY, MEETING IN ROCHESTER, N. Y., THAT TWO TENTHS OF A GRAM OF "HEAVY" NITROGEN CAN BE PRODUCED EVERY 24 HOURS, A SPEED 100 TIMES GREATER THAN PREVIOUSLY ATTAINED. THE COLUMN, A COUNTERCURRENT "SCRUBBING" APPARATUS OF THE DISTILLATION TYPE, CONTAINS 1,200 STEEL CONES FITTED INTO A SIX-INCH PIPE TOGETHER WITH ALTERNATE CONES ATTACHED TO A ROTATING ROD IN THE CENTER, PROVIDING A LARGE SURFACE FOR REACTION BETWEEN AN AMMONIUM SULFATE SOLUTION AND AMMONIA GAS.

versity School of Medicine, was able to establish that hippuric acid, or benzoylglycine, present in foodstuffs, is directly absorbed through the intestinal wall, thereby solving one question concerning the body's chemical disposal of a waste product. Dr. Schoenheimer, together with David Rittenberg, Albert S. Keston, Sarah Ratner and Mr. Fox, reported this first research employing heavy nitrogen as a "tagged" atom in a paper read on September 7 before the Division of Biological Chemistry of the society.

The first partial separation of the isotopes of potassium, another element vital to life, and a factor in regulating heart beat, is also announced by Dr. Urey, T. Ivan Taylor, of Columbia University, and Dr. A. Keith Brewer, of the U. S. Bureau of Chemistry and Soils. A 5 per cent. increase in the normal concentration of potassium of atomic weight 41 has been obtained in the Columbia laboratories by chemical means, a shift in the potassium isotope abundance hitherto found impossible. The method was originated by Dr. Urey and Mr. Taylor for their work on potassium and lithium isotopes.

Analyses show that the occurrence of the three potassium isotopes of atomic weights 39, 40 and 41, vary in minerals, seaweed and the marrow of bones. In bone marrow, where red blood cells are produced, the relative amount of isotope 41 is greater. The very rare isotope 40 is known to be radioactive. Isotope 39 is the abundant one.

"If 41 is increased in concentration in life, it is reasonable to conclude that 40 would be also," Dr. Brewer pointed out. "Isotope 40 is radioactive. Therefore interesting speculations arise as to where experimentation in the separation of these isotopes, so important to the biochemistry of plants and animals, may lead."

The total amount of heavy nitrogen in concentration obtained at Columbia was as follows: 20 grams containing 2.5 per cent. of the heavy isotope; 33 grams of 2.34 per cent. concentration; 400 grams of lower concentrations.

The heavy isotope of nitrogen, which has an atomic weight of 15, is normally present to the extent of .38 per cent. in all nitrogen, that is, one nitrogen atom in every 263 is of the heavy variety. It was discovered by S. M. Naude, of the University of Chicago, in 1929. Ordinary nitrogen has an atomic weight of 14. A rather rare element, nitrogen is an important constituent of protoplasm and of all proteins. It is utilized by plants and animals in nutrition, following a continuous cycle through nature. The waste matter of animals is high in nitrogen content. About four fifths of the atmosphere is composed of nitrogen, and it also is found in ammonia, explosives, dyes and fertilizers.

To concentrate the heavy nitrogen, Dr. Urey and his coworkers used a countercurrent "scrubbing" apparatus of the distillation column type, originally designed by Dean George B. Pegram, of the Columbia Graduate Faculties, and recently employed in the successful mass production of the heavy isotope of oxygen. It is thirty-five feet long and contains 1,200 steel cones fitted into a six-inch pipe. Alternate cones are attached to a rotating rod in the center of the column, thus providing a large surface for reaction.

A slight variation in the physical and chemical properties of the nitrogen isotopes makes possible the process, which depends upon a difference in distribution of nitrogen isotopes between a liquid solution and a gas. In other words, the atomic weight of nitrogen in ammonia gas which is in equilibrium with a solution of ammonium sulfate differs from that of nitrogen in the ammonium sulfate by about five parts per million.

A solution of ammonium sulfate, which is an important constituent of fertilizers, is allowed to run down through the center

of the column while ammonia gas rises from the bottom of the column. The ammonia gas dissolves in the solution; the ammonia molecules, each containing one atom of nitrogen and three atoms of hydrogen, leave the gas and go into the solution, changing places with the ammonia molecules in the solution.

The resulting ammonium sulfate solution contains about 2 per cent. more heavy nitrogen than did the ammonia gas, because the heavier atoms tend to stay in the liquid, while the lighter escape in the gas. There is thus a net flow of heavy nitrogen to the bottom of the column. As the solution collects at the bottom of the column, the ammonia is removed from it and sent upward through the column in the form of gas, again reacting with the ammonium sulfate to create a solution still richer in heavy nitrogen.

This process of reconversion becomes continuous, reaching an efficiency by which two tenths of a gram of heavy nitrogen is produced every twenty-four hours in a concentration six and one half times that which normally exists. Only one thousandth of a gram of heavy nitrogen in twenty-four hours had been previously achieved—a quantity too minute for most research purposes.

While this chemical method was proposed by Dr. Urey in 1935 and some separation of the nitrogen and carbon isotopes was secured about a year ago, this is the first time that such a large separation on an extensive scale has been obtained. Professor Gilbert N. Lewis and Dr. R. T. MacDonald, of the University of California, have used a similar method to secure an appreciable separation of the lithium isotopes.

CORRESPONDENT

RACIAL DIFFERENCES

DR. FRANZ BOAS, the leading anthropologist now living, who retired from his professorship in Columbia University last year at the age of seventy-seven years, holds that no fundamental differences among the races have been proved. It is difficult to understand this point of view, for in the course of evolution there has been a development of intelligence and other traits, and it is improbable that the different races should now be on the same level. In the artificial variations of the lower animals created by us there are great differences, both in physical traits and in behavior. We have the Shetland pony, the nervous and bony race horse, the stolid and massive Percheron. The dogs vary from the lap-dogs of the ladies to the great Danes, from the clever sheep-dog to the stupid bull-dog.

ANITA LEGANA WITH TROPHY

But the contention of Professor Boas is supported and common sense is confounded by the apparent equality of the human races in athletic performance. Most people still remember that a Negro was the hero in the recent Olympic games. The writer of this note happened to be present when the final association football game was played in the Olympiad at Amsterdam

LEFT TO RIGHT: DONALD BUDGE, HALCOMBE WARD, BARON VON CRAMM

some ten years ago. A dozen or more nations contended; the victors were from Egypt and the Argentine. England did not play, as she claimed that the players on the Argentine team were not amateurs because their wages as factory workers were continued during their trip to Amsterdam. As a matter of fact they were true amateurs, for they probably worked in the factory ten hours a day for six days a week and only played football as a sport on Sundays. The English were probably professionals, for it is likely that their principal concern was with sports and they had been trained by paid coaches.

Tennis perhaps is the best evidence for the similarity of different races in their muscular and nervous equipment. The international champions and their runners up come from many nations. At the recent games at Forest Hills, which are the occasion of this note, the finals in the men's singles were between an American and a German, in the women's between a Pole and a Chilean. The Californians, and especially their Helens, have probably done so well not through physical superiority, but owing to climatic and social conditions.

There are obvious physical differences between the sexes. As the policeman said to the woman who wanted to know why she could not bathe in the same attire as the men, "women is different." The psychologists have found it difficult to find measurable differences in mental equipment. One of our most distinguished psychologists found in experiments in the association of ideas that women thought more about dress than men; another psychologist of nearly equal standing found the opposite—the former was a man, the latter a woman. The accompanying picture does illustrate a difference that appears to be real.

Budge could not faint from excitement over winning a tennis match after two sets.

Herr Hitler knows about the playgrounds of Eton and the methods of Sparta. When long ago the writer of this note was a student in Germany, there were in the universities no athletic games except sport duels. He, however, played football several times in a Polytechnic school and could at any time run through the line to the goal, for though he weighed only a hundred and fifty pounds the players respectfully moved out of his way. Now all this is different, but not through any racial change.

Incidentally it may be remarked that even the physiognomy of the races varies less than is commonly assumed. In the photograph many will think that one man looks like a German, the other like an American. But if photographs of ten Germans and ten Americans are mixed it is difficult to sort them out, apart from their hair and clothes. Indeed under these conditions it is difficult, often impossible, to discriminate criminals from clergymen, men from women. The winning woman in the picture might have come from any Caucasian race.

The problem as to whether national differences are frequently set by inheritance or are functional and due to environmental conditions is of fundamental importance. Do "nations delight to fight because it is their nature to," or only because they have been badly brought up? May not wars disappear as quickly as duels when their futility is realized?

J. McK. C.

ANITA LEGANA BEING CARRIED OFF THE COURT AT FOREST HILLS, LONG ISLAND